The NEW IMPROVED Poor Man's JAMES BOND

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Kurt Saxon

YOU ARE THE LAW!

by Kurt Saxon

Due to budget cuts a Missouri sheriff's department closes down at 5 pm. Callers get a recorded message saying, in effect, "Defend yourself as best you can until tomorrow".

Violent crime rose 12% in 1986.

Prisons are so crowded, thousands of criminal psychotics are given early parole. Cases of murder, rape and every other vicious crime have been reported as a direct result of loosing these animals.

Mental institutions are so selective that an applicant has to prove his eligibility by killing at least one of the examiners. The fellow who killed 21 McDonald's customers a couple of years ago had been refused mental help just a few days previous to the massacre because he seemed in pretty good shape, all things considered.

Most police agencies are understaffed, overworked and their officers prone to battle fatigue. It is increasingly hard to get a collar put away for the period determined by his offense. Officers often ignore crimes they feel our Liberal courts would allow to be plea-bargained out of the over-crowded docket. There are even cases of cops ignoring a mugging while staked out for a large drug bust. So you can actually be attacked, robbed, raped, maimed or killed while a cop looks on.

Drugs have become such a fixation with our lawmen that their suppression has effectively emasculated police sworn to "Protect and Serve". Besides, every cop who makes a drug bust is, in effect, working for the drug dealers. Their valiant, though counterproductive efforts serve only to drive up the prices of drugs. This greatly increases your chance of being mugged or burglarized by losers needing more money for a fix.

The only solution to the drug problem is total legalization. This would take the profit from the trade. The losers who prey on society to support their habit could then destroy their already inferior brains at little cost and no danger to the taxpayer.

Why should billions be taken from our economy by the Drug Enforcement Agency, junkies robbing to support their habit and court time? Who cares if a loser, born to no purpose, destroys his brain? Wouldn't your child be less likely to get on drugs through peer pressure if one of his already hooked peers had nothing to gain? And wouldn't you rather a junky blow his mind with over-the-counter narcotics than maim or kill you or one of your loved ones for the money to buy from a pusher?

Our great-grandparents could buy any narcotic over-the-counter. Drug-induced crimes were too rare to document. Drug addicts not only had no need to prey on society to support their habit but they soon died, taking their inferior selves out of the gene pool.

Now, babies are born showing withdrawal symptoms. Hundreds of thousands of degenerates are breeding like rats, both out of ignorance and to get more Aid to Dependent Children so as to buy more drugs.

The Secret Secret Agent's Lab!

Just imagine you were the real 007. After saving your country a dozen times, you are in disgrace. This is is because, at a party, you gave the queen a playful goose, causing her to spring into the punch bowl. So you were fired.

No longer the clever gadgets, the fancy and lethal cars. And all those girls? Now even Moneypenny won't give you a tumble. Poor baby.

But you've still got all those enemies you've made during so many movies. You are now cut off from MI-5 and on your own. Now you'll have to equip yourself to survive and defend your nation. Unauthorized and even forbidden to engage the foe, you must keep your activities secret from police, landlords and especially relatives living with you.

Of course, while making all your own weapons, you'll need a cover story to explain your workshop and lab. Aside from the other volumes of THE POOR MAN'S JAMES BOND, I advise you to get GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY and all the volumes of THE SURVIVOR. With all this information, you will be able to create an arsenal while leading others to think you were only trying out the old formulas and crafts.

Although the chemistry book shows how to make many compounds from simple, easy to get chemicals, you may want to order many chemicals and lab

This was exemplified on a recent Phil Donahue show. The stage was crowded with cribs of "boarder babies". These were the pitiful offspring of junkies who were too far gone to care for their socially doomed young. "What to do about the situation?" was the theme of the segment.

Somehow, a rational caller got through who said that all their mothers should undergo mandatory sterilization. Phil moved on without addressing himself to the only realistic solution suggested. Nor did any in his audience refer to it. Both Phil and his entire studio audience seemed o believe that something should be done to help those uined children. Of course, nothing could be done, but reventing more of the same was out of the question.

So more women will have more ruined babies. They will lso spread AIDS through dirty needles and prostitution nd have more babies while Phil and his Liberal audience ammer their impotent sympathy.

But I digress. Getting back to the subject of you, the rivate citizen being the law, is my purpose.

Not too long ago, officers engaged in public relations ould lecture civilians on how to keep from being injured y social predators. Their advice was non-resistance. Give him what he wants and he may not hurt you".

This no longer holds true. Increasingly, more predators re those prematurely released from nuthouses and prisons. hey are criminally psychotic and consider the bodily inury of their victims the icing on their cake. They have o fear of punishment since they are used to prison or ave papers saying they are mentally ill and so are not esponsible. So why shouldn't they tear you to pieces aftr they've gotten your wallet or raped you?

One argument against resistance to the mugger, armed obber or rapist is that a show of counter-force might ake him mad at you. But, Dear Heart, is not a monster hreatening your life already mad at you?

This brings to mind a classic news account of a rape, efore the word "rape" was in common use. "He beat her up, nocked her teeth out, threw her downstairs, breaking her eg, and then attacked her".

Getting back to your being the law; you've heard of the erm "Citizen's Arrest". This means that a citizen witnessing a crime where there are no police present is legally mpowered to arrest the lawbreaker. Such arrests have only een made in the case of non-violent offenders. I've never eard of a mugger or rapist being treated to a citizen's rrest. Even so, if the citizen making the arrest failed o "read him his rights" would not he be released?

So forget citizen's arrests. Also, don't be bothered by ny objections to taking the law into your own hands. When ou are confronted by an assailant you are the law. Morever, in anticipation of being forced to act against an ttacker, go armed.

With your chances of being a victim going up all the ime, the penalties for carrying a concealed weapon become ess important. Even so, as a California police captain old me years ago, "Better to be judged by twelve than arried by six". Besides, if you aren't accustomed to beng searched, how would carrying a concealed weapon make ou more likely to be searched?

As the crime rate rises, the Liberal media continues to ntimidate the citizen who would exercise his duty to eliinate predators. Bernhard Goetz is still being tried for hooting four vermin. Berny's only crimes were in not kiling them all and in then giving himself up.

A lesser crime was in his pleading self-defense. I hate hat term. If you limit your action to defense, which he idn't, an attacker can break through your defense. The dea is to attack with the intention to maim or kill your ttacker.

What most people don't realize is that a mugger, rapist, burglar, etc., chooses his victims for their vulnerability. He's not a challenger. He doesn't want any resis-

supplies ready-made. Your best source is the hobby chemical companies advertizing in the classifieds of Popular Science and Popular Mechanics.

Of course, such companies have removed just about all of the oxidizers like the chlorates and nitrates, plus acids and anything else a child may do damage with. But they do offer the full range of lab equipment such as rubber tubing, glass tubing, retorts, flasks, test tubes, etc., that you may not want to take the trouble to make yourself.

An even better source for chemicals is your local pharmacy. It would be best if it was one near a hospital, as they usually have more chemicals in stock, such as strong ammonia, formaldehyde, etc.

You don't just walk up to the pharmacist with a list of chemicals and lab gear. Most of his time is spent filling prescriptions and he makes a good living at it. He would make a profit ordering chemicals and lab gear for you but not enough to interrupt his routine. So you have to be very clever and get to his ego and also his unorthodox interests.

Every pharmacist is somewhat of a mad scientist in his own fantasies. You must get him to accept your own interest in weird projects without arousing any suspicion or taking up too much of his time.

You start by saying a few cheery words to him on a couple of occasions when you see he's not too busy. Most pharmacists are really nice guys but if he's just an old poop, go on to the next one.

Your best bet is to show him a copy of GRANDDAD's WONDERFUL BOOK OF CHEMISTRY, especially the section on chemical magic. Tell him you are interested in stage magic with chemicals but don't know how to get the chemicals. You may even loan him the book. At any rate, it will be your best smokescreen, giving you a legitimate, if odd, excuse for wanting just about any chemical you feel a need for.

tance. A counterattack is usually the only way to keep from being victimized. And that usually means any form of counterattack.

A predator bent on gain from someone he considers weaker will change his mind quickly if attacked by his victim. After all, he doesn't want to press charges against a victim. Nor does he want to explain a wound which has to be reported to the police. In most cases, he simply can't afford resistance to any degree.

Even so, the media still warns against counterforce against attackers. Last week a Little Rock TV station did a report against stun guns by Doug Hurst. The argument was that the stun gun wasn't effective against everyone and it would take about three seconds to immobilize an attacker, the inference being that the attacker could disarm a smaller person in those three seconds.

That was nonsense. Anyone unaffected by 50,000 volts is from another planet. Even a 35,000 volt stun gun will stop an attacker instantly. And sure, one can do a lot in three seconds. But the stun gun immobilizes instantly and the longer the contact is maintained, the longer the attacker will be immobilized. So simple contact will make an attacker helpless. If the contact is maintained for from three to five seconds, the attacker will be paralyzed for from four to eight minutes. In that time you can handcuff him and take his wallet. (Spoils of war).

One thing to keep in mind is to never threaten a mugger or any other attacker. Use on him whatever you have. In most cases he would run. But if your weapon seems puny or if he has a longer reach, you might not be able to do as much damage to him as if you take him unawares.

Actually, any harm you can do to an attacker will be very likely to cause him to flee. We're not concerned with "stopping power" here. Stopping power usually applies to an assailant dedicated to harming you as an individual. He may be a doped-up psycho bent on rape or mayhem for its own sake. In that event you might as well do as much damage as you can since you are at risk regardless of your behavior.

In most cases concerning junkies, they are not high. They want money for a fix and are hurting. They don't want any more pain. A .22 Stinger, a stab wound from a knife pen or even a "Key Buddy" knife will be sufficient.

Last week I was gratified by a caller who told me I may have saved the lives of his wife and himself. He told me they were in a foreign country and were accosted by a knife-wielding punk who demanded their money. The caller had one of my fangs in a narrow pocket he had had his wife sew beside his wallet pocket. The fang pocket was snug enough to retain the cap as the fang was withdrawn.

The caller removed the wallet and fang at the same time and as he handed over the wallet he shoved the potassium cyanide loaded fang into the punk's stomach.

As expected, it had registered in the fool's mind that something had been done to him. He paused momentarily to see if he was hurt. The caller estimated that it took only from four to six seconds for him to drop dead. As it happened, police were nearby and took the body away, assuming the robber had had a heart attack. The caller wasn't held.

But the caller was sure, from the demeanor of the punk, that had he not been fanged he would have stabbed them both. The police were there only by coincidence.

Aside from being able to destroy vermin who might be a threat to you, you ought to reach out as a responsible protector of your community. If you are at loose ends, you ought to become a cop. Failing that, there is always the National Guard. At least join your local neighborhood watch. Without a sense of community responsibility you won't count for much in the long run.

A sure way to get lab gear and even a pretty fair assortment of chemicals is to call up highschool and college chemistry lab teachers, after class, Tell them you are looking for second-hand lab gear and would appreciate it if they would tell you if they knew of any graduating students who might wish to part with their old lab gear. I've come upon good buys from ex-chemistry students who were through with their equipment. It's usually just taking up space and they are glad to get rid of it for very little.

Teachers are often very helpful on behalf of such students and also, one might even have some school lab gear that has been replaced with new equipment. You might also ask the teachers where to buy lab gear and chemicals.

Another way is to put an ad in your local newspaper's classifieds under "Wanted". Example, "Wanted: Beginning chemistry student wants second hand lab gear and chemicals. (phone)". You might also tack such an ad on highschool and college bulletin boards.

If you put your mind to it you can gradually accumulate all the lab gear and chemicals you want. But just to prepare you for the time when you may have to make your own lab gear you should learn to make all the practical lab gear you can from odds and ends.

The following calls for a lot of glass and rubber tubing which is easy to get from any pharmacy or chemistry catalogue. Even so, copper tubing in various sizes from your local hardware store can often be substituted for glass tubing. Most glass tubing is used for leads from stoppers to which rubber or plastic tubing is attached. To bend copper tubing without crinkling, you fill the tubing with sand.

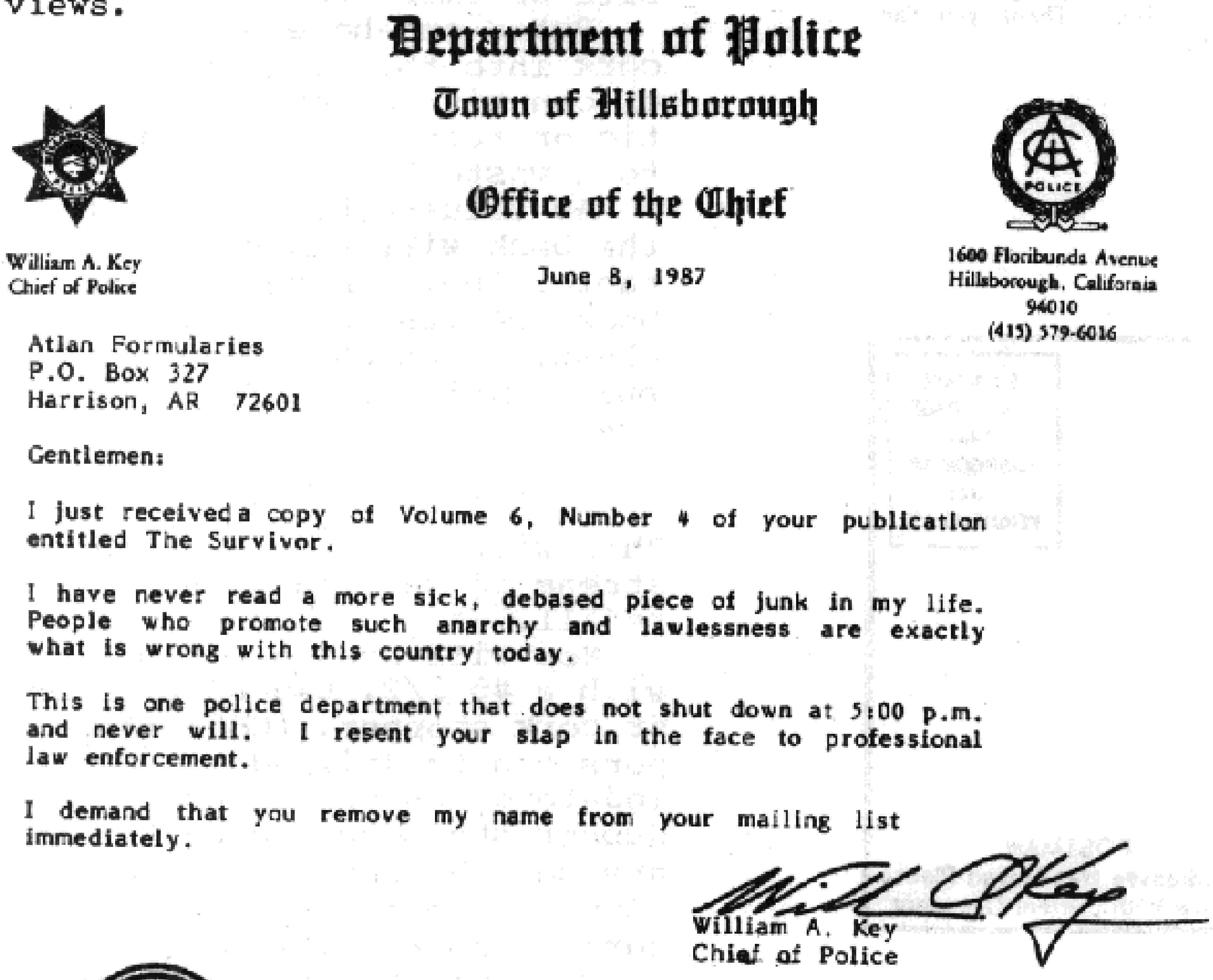
Regular corks of all sizes can be bought from any large hardware store. The cork is drilled to snugly accommodate glass or copper tubing.

Plastic tubing can also be bought from the same hardware store in all sizes. It is al-

COPS TURN THUMBS DOWN ON INTELLIGENCE

by Kurt Saxon

In my last editorial I stressed the fact that as our system degenerates, the police will be even less able to protect the public. It was not an anti-police article. However, even though the police are increasingly unable to protect the public, they were greatly offended by my views.



Department of Police
Town of Hillsborough
Office of the Chief

William A. Key
Chief of Police

1600 Floribunda Avenue
Hillsborough, California
94010
(415) 579-6016

June 8, 1987

Atlan Formularies
P.O. Box 327
Harrison, AR 72601

Gentlemen:

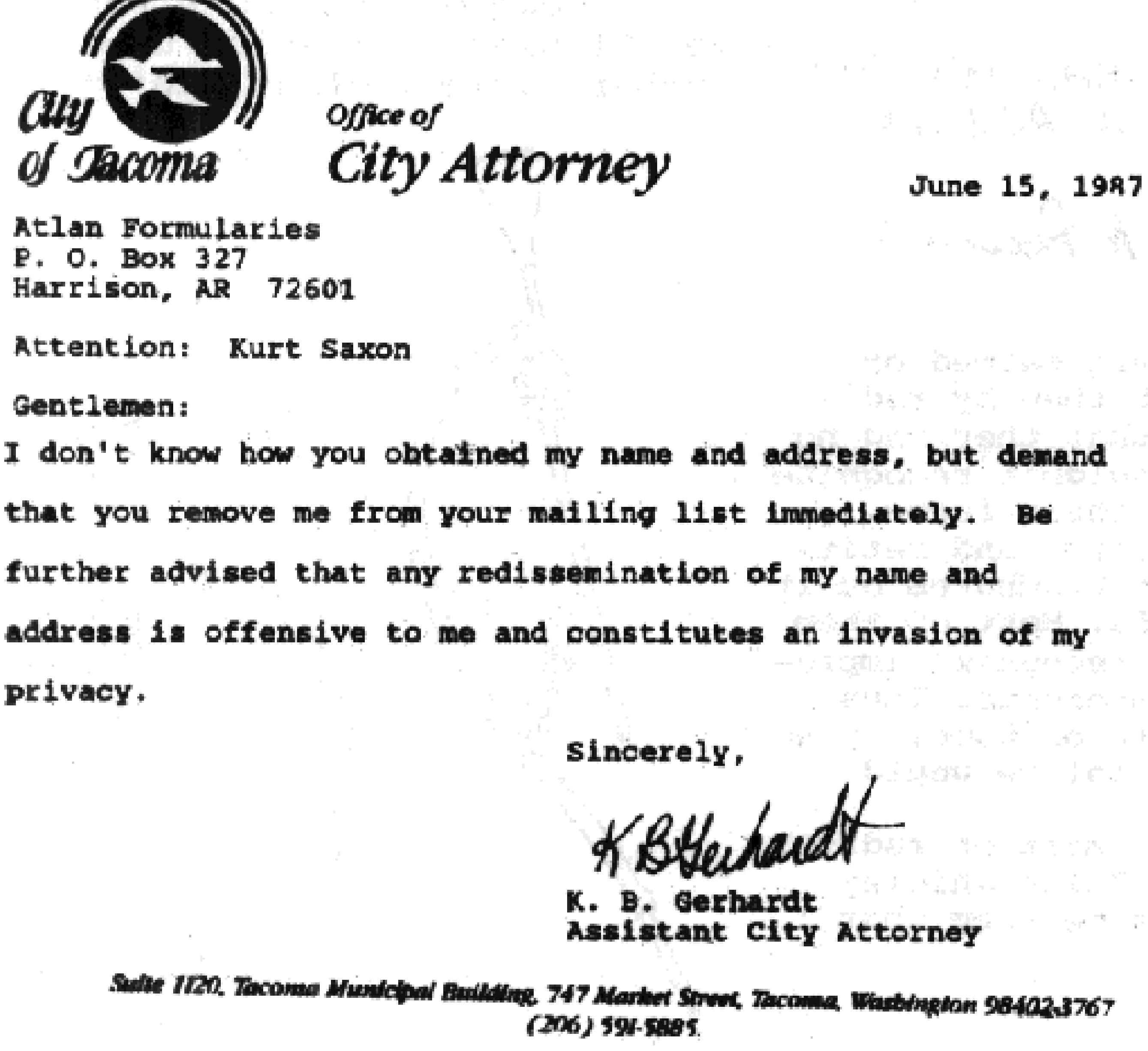
I just received a copy of Volume 6, Number 4 of your publication entitled The Survivor.

I have never read a more sick, debased piece of junk in my life. People who promote such anarchy and lawlessness are exactly what is wrong with this country today.

This is one police department that does not shut down at 5:00 p.m. and never will. I resent your slap in the face to professional law enforcement.

I demand that you remove my name from your mailing list immediately.

William A. Key
Chief of Police



City of Tacoma
Office of City Attorney

June 15, 1987

Atlan Formularies
P. O. Box 327
Harrison, AR 72601

Attention: Kurt Saxon

Gentlemen:

I don't know how you obtained my name and address, but demand that you remove me from your mailing list immediately. Be further advised that any redissemination of my name and address is offensive to me and constitutes an invasion of my privacy.

Sincerely,

K B Gerhardt

K. B. Gerhardt
Assistant City Attorney

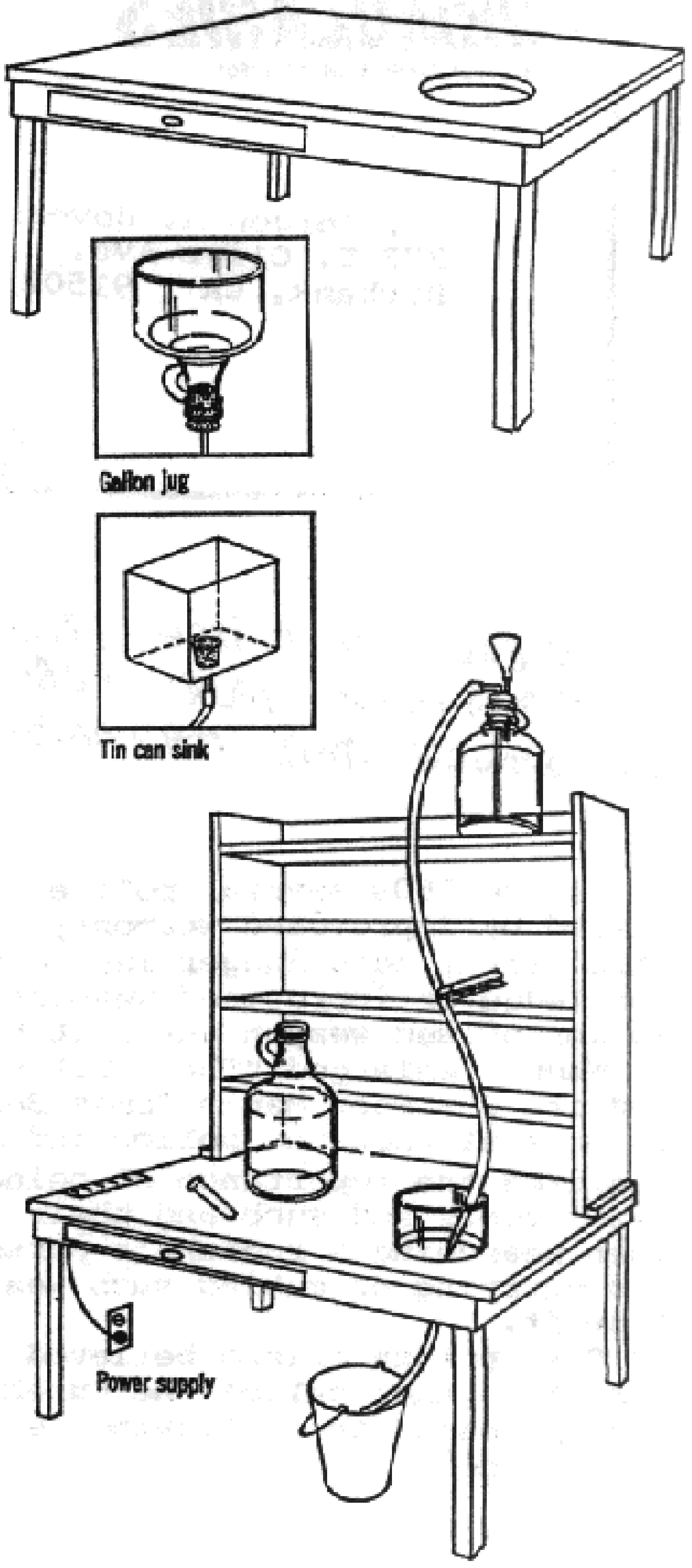
Suite 1120, Tacoma Municipal Building, 747 Market Street, Tacoma, Washington 98402-3767
(206) 591-5885

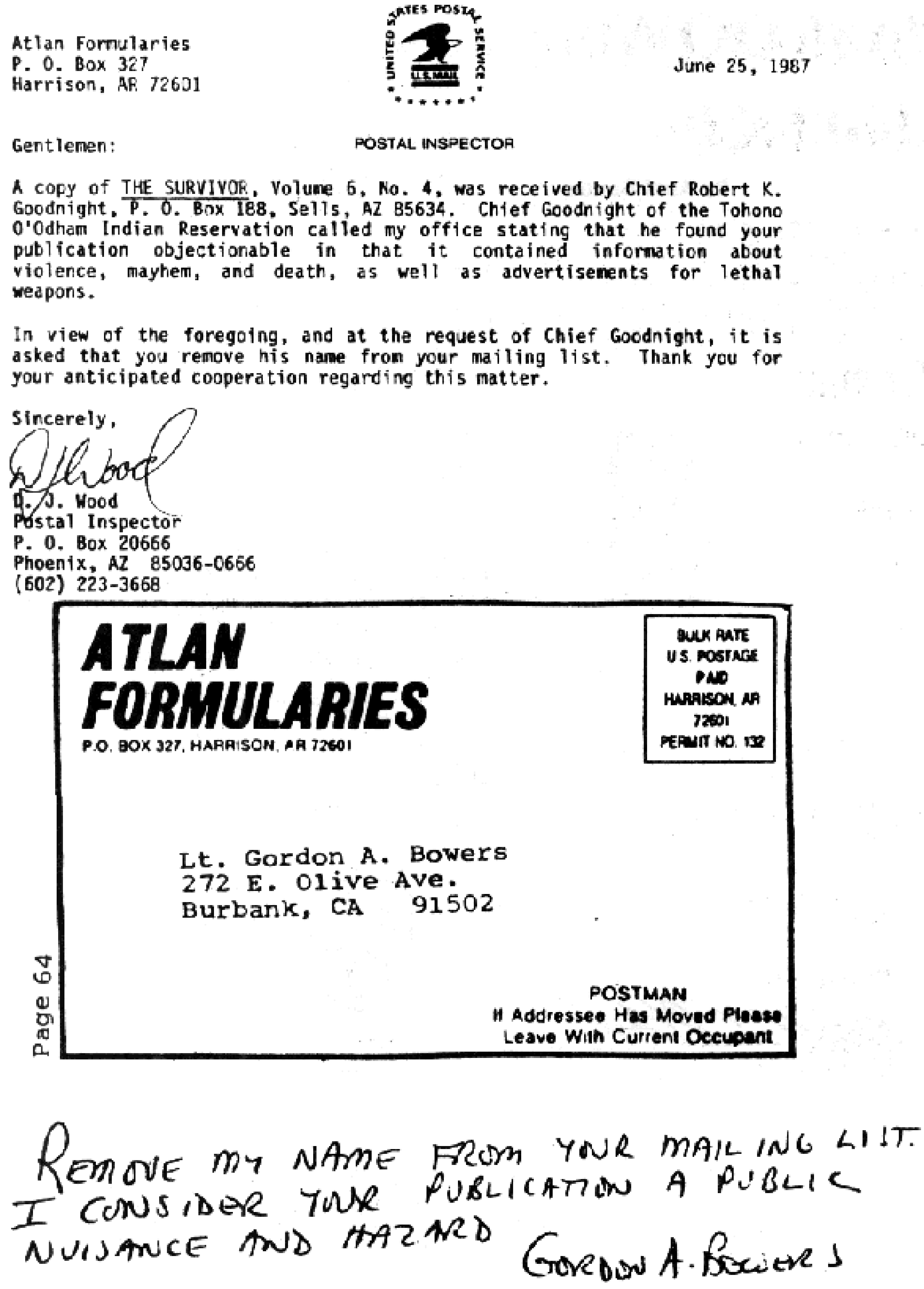
most as good as rubber tubing but tends to go limp with any heat. This can be remedied by tying a string around the drooping section and suspending it up away from the heat.

WORK TABLE

You can't properly organize your projects without a suitable work table. Any old table will do as long as it's sturdy so it doesn't wobble. You can get such a table very cheaply from your local junk shop, Good Will or Salvation Army store.

You'll need a round hole in the table to accommodate the top half of a gallon jug used as a sink. You can also use an oblong gallon can. If a jug, make the hole slightly smaller than the diameter of





Atlan Formularies
P. O. Box 327
Harrison, AR 72601

POSTAL INSPECTOR

June 25, 1987

Gentlemen:

A copy of THE SURVIVOR, Volume 6, No. 4, was received by Chief Robert K. Goodnight, P. O. Box 188, Sells, AZ 85634. Chief Goodnight of the Tohono O'Odham Indian Reservation called my office stating that he found your publication objectionable in that it contained information about violence, mayhem, and death, as well as advertisements for lethal weapons.

In view of the foregoing, and at the request of Chief Goodnight, it is asked that you remove his name from your mailing list. Thank you for your anticipated cooperation regarding this matter.

Sincerely,

D. J. Wood
Postal Inspector
P. O. Box 20666
Phoenix, AZ 85036-0666
(602) 223-3668

ATLAN FORMULARIES
P.O. BOX 327, HARRISON, AR 72601

BULK RATE
U.S. POSTAGE
PAID
HARRISON, AR
72601
PERMIT NO. 132

Lt. Gordon A. Bowers
272 E. Olive Ave.
Burbank, CA 91502

POSTMAN
If Addressee Has Moved Please
Leave With Current Occupant

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REMOVE MY NAME FROM YOUR MAILING LIST. I CONSIDER YOUR PUBLICATION A PUBLIC NUISANCE AND HAZARD

Gordon A. Bowers

In the '60s several police officers were maimed or killed by improvised weaponry directed at them by radicals. Their main danger lay in the fact that they had no knowledge of improvised weaponry. They couldn't recognize an improvised weapon until it blew up in their faces.

When I enlarged "The Militant's Formulary" and retitled it "The Poor Man's James Bond" I sent brochures on it to several thousand police and fire chiefs. Most of them realized the importance of being able to recognize improvized bombs and such and their common components. Thus, when searching a radical's person, vehicle or home, if he was carrying or making such weapons, the police would know it.

Some police chiefs believed I was some sort of radical myself so they called the Eureka, CA PD. Chief Shipley then prepared the following letter to assure them that I was on their side.

the jug. If a can, cut about a half inch down at the corners and bend outward so the flaps will rest on the table top.

To cut the hole, first drill a hole through and then use a keyhole saw to cut the shape you choose.

To cut the jug in half see the bottle cutter further along. Smooth the edges with a file or emery paper.

Put a one-hole stopper or cork into the neck of the jug or can with a length of plastic or rubber tube leading into a waste bucket.

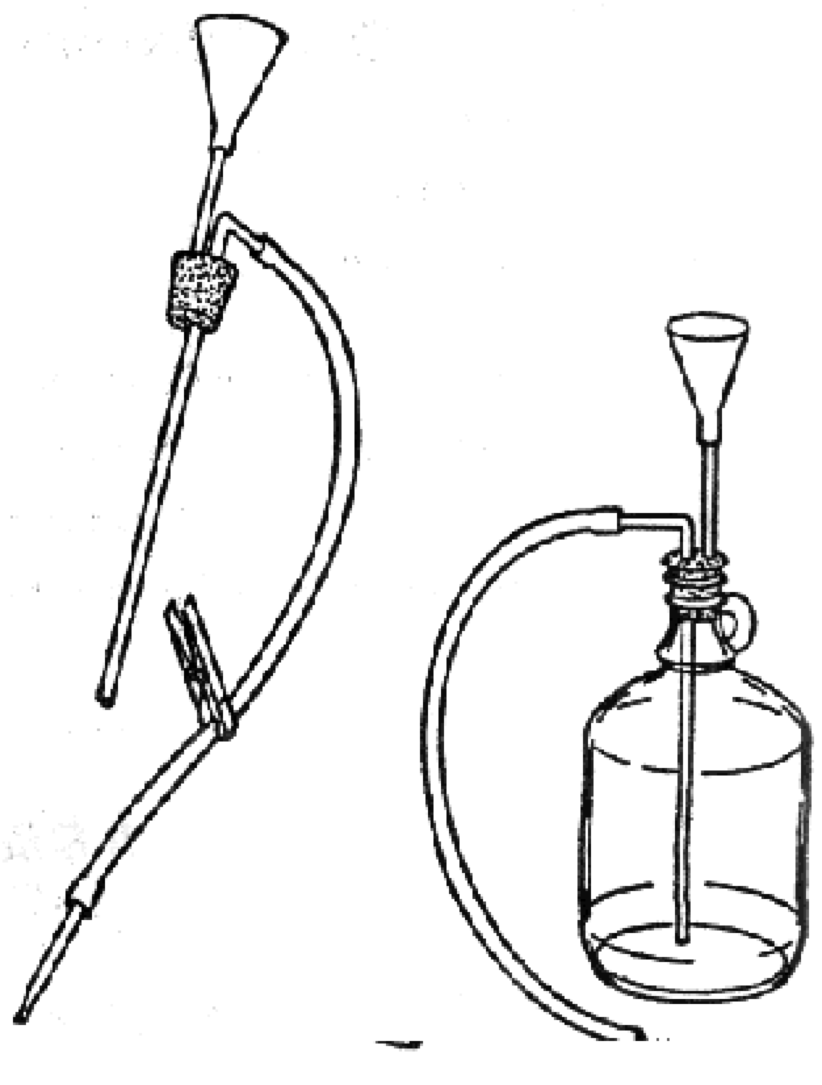
As illustrated, shelves at the back will finish your lab table. They can be a set of book shelves, also bought very cheaply second-hand or can be built with 1 x 12 inch scrap lumber.

GRAVITY WASH BOTTLE

This will give you a steady stream of water and is easy to refill.

You will need a gallon jug with a #6 1/2, two-hole rubber or cork stopper. (Cork stoppers can be drilled to accommodate glass or copper tubing. Rubber stoppers are better and are sold by any hobby chemical supply company. But in a pinch cork stoppers will do).

To complete the wash bottle you'll need a plastic funnel, rubber tubing, glass tubing



CITY OF EUREKA
P.O. BOX [illegible] - EUREKA, CALIFORNIA [illegible]

This is a copy of the letter sent out by Chief O.R. Shipley, of the Eureka Police Department to civil authorities who enquire about "The Poor Man's James Bond" and its author.

In regard to your inquiry about Mr. Kurt Saxon, Mr. Saxon, aka Don Sisco is a permanent resident of the City of Eureka. He has authored several books on various subjects. His most controversial book has been "The Poor Man's James Bond".

Mr. Saxon is a recognized expert in the field of explosives and their application. He has made in-depth studies of methods employed by the more militant groups. He is a former member of the John Birch Society, the Minutemen and several other extreme right wing organizations. However, over the years he has mellowed and is no longer affiliated with these groups.

Mr. Saxon is very pro-establishment and pro-law enforcement. This department uses Mr. Saxon's expertise in training programs.

Mr. Saxon wishes only to sell his more sensitive books to law enforcement and fire agencies to serve as training manuals in the recognition of bombs, bomb components and techniques.

Mr. Saxon will not knowingly sell his more sensitive books to any left wing group or individual. This department feels that a diligent study of Mr. Saxon's books will assist any department in learning the methods and techniques used by militant organizations.

Yours truly,

O. R. Shipley

O.R. SHIPLEY,
CHIEF OF POLICE

The letter was printed about 1972 and I sold a lot of PMJBs. Redstone Arsenal was conducting a training program for police bomb squads and so bought a couple of thousand copies.

Since I believed this generation of cops would profit by having my three volume library of weaponry, I got a directory listing thousands of police officials. I sent a copy of SURVIVOR 6, issue four and the only replies I got were those above. Not one order!

Of course, I hadn't realized the makeup of today's police. The modern cop has been emasculated by our Liberal judicial system. At the same time, he has been equipped with the latest state-of-the-art methods of crime detection along with self-protecting equipment.

So this "cop" patrols his assigned territory in his rolling fortress. He has a shotgun attached to his dash and a pistol at his side. He also has a radio to summon help if he confronts any criminal more dangerous than a crippled shoplifter.

Although cops get a lot of credit for catching the bad guys, they seldom stop them from committing atrocit-

and a clothespin. Plastic tubing is not as good as rubber, as it's too stiff to be mashed by a clothespin. Even so, you can connect a length of plastic straw to the plastic tubing and that will easily close as the clothespin presses it.

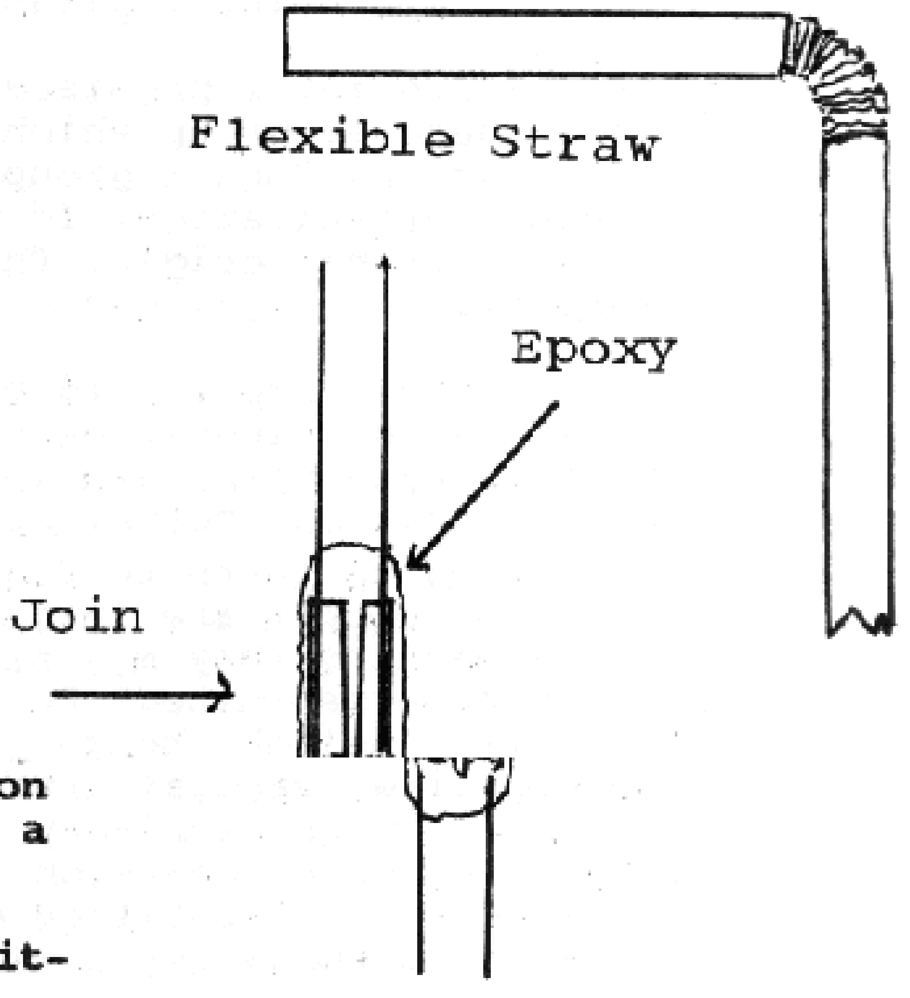
Plastic drinking straws can also be substituted for glass tubing. They are bought at most grocery stores and some are flexible for bending. One thing to note if you are using plastic straws through cork is to smear epoxy around both the entrance and exit points of the cork to make it air-tight.

Plastic straws can be connected, for extra length, Just slit the straw a half inch and push another length in. Then epoxy around the slit and the join and it will be one piece.

If you decide to use plastic tubing, take a plastic straw to the hardware store so as to choose a width which will most easily fit. Whether the plastic tubing goes over or inside the drinking atraw, epoxy is the best substance to use to make the joins tight.

To put the gravity wash bottle together, insert the funnel and tubing through one hole in the stopper. (see the thistle tube, further along). Then put the glass or plastic straw tubing through the other hole, as shown.

To operate, fill the bottle through the funnel. Suck on the end of the tubing to



ies. In short, although he is pledged to "Protect and Serve", the modern cop does neither. He can't. His highly visible patrol car keeps all street crime from happening until he moves on. Then the criminal is at liberty to rob, rape, maim and kill any of the unarmed citizenry he has targeted.

Of course, after the deed has been done, police science steps in. The criminal is often quickly caught. This is no help to the victim. And all too often, if the victim lives, the criminal is out of jail before he or she is out of the hospital.

Our Liberal judicial system is so concerned with the rights of criminals that even the best efforts of the police are wasted. After even the most violent and disgusting outrage, the captured criminal must be treated with exaggerated courtesy. Otherwise he is likely to be set free on the grounds that his arrest was improper and his "Constitutional Rights" violated.

Although there are a lot of good men in our police forces, they are nowhere as effective as when I was young. The admission of women into the forces has naturally lowered the standards of aggressiveness needed in an effective police officer. Also, the overall liberalizing of police forces has kept the more rational men out. This has caused our police forces to be "manned" mainly by nitwits who actually do consider the rights of the criminal more important than those of the victim.

Our national crime rate is accelerating and our liberalized police are becoming less effective at protecting us. So we must protect ourselves and each other.

Naturally, most police are dead-set against citizens meting out justice to predators. To those I would submit the following two scenarios.

Scenario 1: A psychotic breaks into a woman's home with the intent to rape and kill her. An armed citizen, or vigilante, if you wish, goes in, kills the fiend before he can do much damage and then fades away into the night.

Scenario 2: A psychotic breaks into a woman's home with the intent to rape and kill her. No one comes to her aid. When her body is found the next day, the local police track down her killer. He is sent to a mental institution for a few months or prison, where, if he behaves, he will be parolled in three years.

Which scenario would you prefer? If you are the typical modern cop you will consider the commendation you get for the killer's capture more important than the woman's life and the safety of the community. If you chose the first scenario you are approving vigilantism. Shame on you! Shame on me, too.

In my last editorial I promised to tell you how to form a neighborhood defense group which would serve both your community and nation. Such a group would not be connected with any radical organization. It would have no basis in race, creed or national origin. There should be no dues, oaths or commitments to any cause but the safety of the community.

The basis of the group should be a martial arts school. This would not be an Oriental martial arts school, cluttered with alien tradition, discipline, foreign phrases and various uniforms and belts. All that is nonsense to one simply wanting to learn to fight.

Actually, most people are intimidated by the idea of training for something they may never have a need for. How often have you been assaulted? Do you hang around in bars and loiter in slum neighborhoods? If your answer to all three is in the negative, martial arts training will simply fit you to protect your territory from likely marauders as our system goes from recession to depression.

Aside from the nonessential-filled Oriental martial arts schools, there are those two-week combat courses con-

start the flow. Then clamp the tubing with a clothespin.

This gravity wash bottle will give you running water for mixing chemicals.

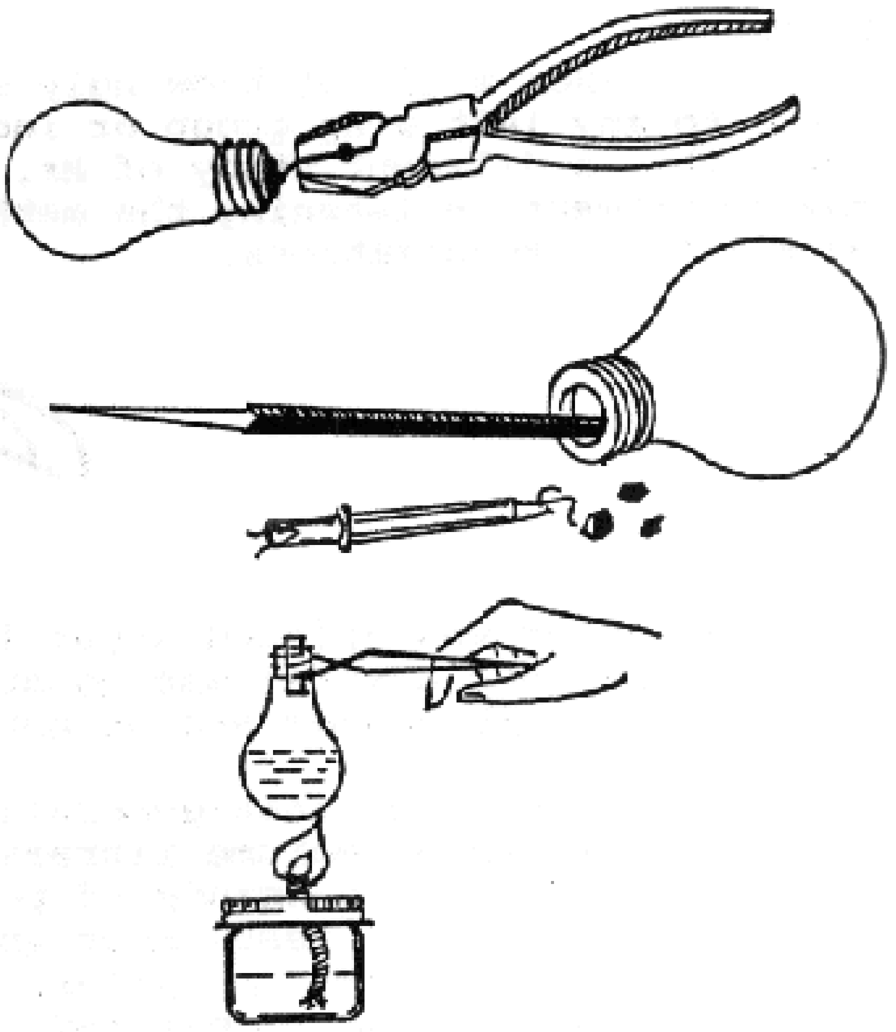
LIGHT BULB CHEMISTRY FLASK

This flask can be heated and used with stoppers and requires only a burned out light bulb.

To turn the bulb into a flask, use a knife blade to bend up and separate the tip from the surrounding baked tar. A pair of needle nosed pliers is better than the pair in the illustration.

Pull off the tip with the pliers and crush and pick out the bits of baked tar. Then pull out the filaments and what you can grasp of the glass pointing up. Now, use any screwdriver, file or whatever, to give a sharp tap to the rest of the glass holding the filaments. Rotate the tool around the inside of the bulb until no more glass juts out.

You will want a clear flask and the frosting is easy to remove. Simply stick a toothbrush inside the bulb and rotate it against the sides. Now all you have to do is rinse the bulb out with water.



CUTTING GLASS TUBING

You really ought to get a few feet of various sizes of glass tubing. Improvisation sisting of running through the woods collecting ticks and chiggers. That's about all such courses amount to. And they average $350.00 per course.

Such quickie combat courses have a potentially fatal drawback. They make a novice overconfident. Simply learning to throw an opponent under the direction of an instructor gives nothing but surface knowledge. The brain may absorb certain rules of hand-to-hand combat but the body has to be trained to make those moves reflexive. Two weeks doesn't do it.

Whatever you do, don't waste money on those stupid Ninja books. "Ninja" is simply a Japanese word for assassin. We have their equivalent in the Mafia hit man. You don't need to practice creeping, climbing, crawling and clawing for several years just to put a bullet or knife into some slob.

Besides, there is no proof that the black-clothed, gadget-encumbered Ninja of the films and those ridiculous books ever existed as portrayed. Also, where were the Ninja on Guadalcanal or Guam? I'm sure the Japanese military would have used them if they'd had them.

If the films and books are to be believed, a half-dozen Ninja could have gone behind the American lines and wiped out every Marine contingent. The idea is not without precident on our side.

A Mafia hit-man was drafted for WW II. One night he slipped behind the German lines and found a company of soldiers, asleep and mostly huddled together for warmth. He slit the throat of one, ear-to-ear, while he was lying next to a buddy. When the other awoke, he went mad. The whole company was demoralized and paniced. The idea that an American could get that close to sleeping but heavily guarded men far from the front lines was a mind-blower.

Then there was Kommando leader Otto Skorzeny's men who dressed in American uniforms and infiltrated American units. You've probably read of the havoc and confusion just a few of them caused in the American lines.

If Mafia men could be drafted, so could Ninja in the Yakuza. "Greetings" from Hirohito meant the same thing as from Roosevelt. Conclusion: the Ninja and their prowess are largely mythical. Don't waste your time and money.

Getting back to starting a group; first develop something to attract the kind of people you want. This would be a martial arts school which would be affordable, informal and effective. Give an office worker a place he can go to three nights a week and go from Jiu-Jitsu (Judo), to lethal combat in easy stages and you'll have all the customers you can handle.

Say you have no experience in martial arts. That's best, actually, since you won't have to unlearn a lot of nonsense you might have picked up from a formal school. So, starting fresh, you choose as a partner, a friend you can get along with and enlist him as a business partner and fellow-trainee.

Start with Jiu-Jitsu in PMJB 2. Learn and practice each lesson until it is reflexive to both of you. This should take a couple of hours each evening for about two months. By now you should be a match for just about any moronic roughneck who might threaten you.

Having mastered Jiu-Jitsu, go to the Army course in PMJB 1. Learn every attack and defense there until both of you are an even match. Next, master the Marine course and consider yourselves ready for business.

Most towns have empty stores on the square or near it which can be rented cheaply. All you need are a couple of wrestling mats, a sign reading "American Martial Arts" and some newspaper ads. You might also talk to your local reporters about the school. In your ads and interviews, tell people your school will teach self-defense to anyone for only $25.00 per week in easy two-hour sessions three times

keens the mind but you must not take it to extremes.

So let's say you've gotten a supply of glass tubing from your pharmacist, a chemical catalogue or your friendly sign maker, who has access to glass tubing for neon signs. Working with it will not only give you new skills but better lab equipment. Also, it's fun.

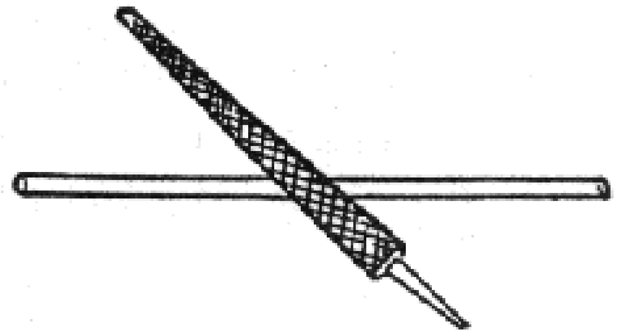
To begin, place a length of glass tubing on a smooth surface. Decide where you want to break it and give that spot a sharp rake with a file. Then, grasp the tubing firmly with your thumbs near the mark. Now bend the glass back from the mark and it will snap cleanly.

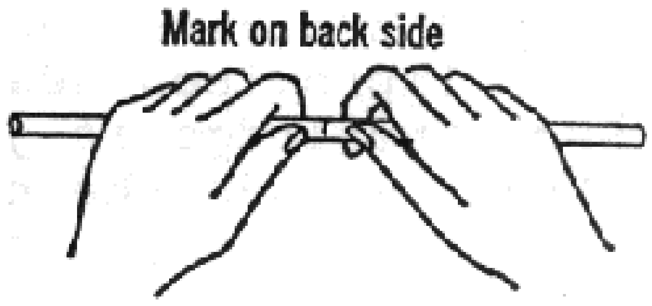
To insert the pieces of tubing into the rubber stoppers or corks, dip them first in soapy water so they will slip in easier. If you use corks, epoxy around the tubing on both sides.

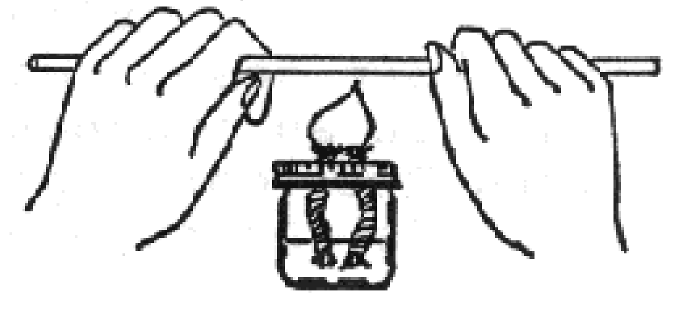
BENDING GLASS TUBING

Basic glass bending is very simple. The part to be bent is held over the flame and rotated until it glows red all around. Then bend it. Now, hold it for about ten seconds until it hardens.

An alcohol flame is not so hot as a gas flame from a bunsen burner or a propane torch. Actually, you can buy a propane torch with all its attachments cheaply from the hardware store. It can be put







per week. Most people can afford that and only 100 customers would give you $2,500.00 per week.

Open up from 2:00 pm to 10;pm six days per week. That would give you eight two hour classes each week. Figure on from ten to twenty students per class; mostly women from two to six pm and mostly men from six to ten pm.

The idea would be to teach each student the basics and have him or her practice with another while you and your partner coach and watch so no one gets hurt.

You might consider stocking my books in your school. Each student would buy PMJB 1 and 2 and probably 3 and the Survivor series. In this way they could study the moves in PMJBs 1 and 2 and so would have a clear idea of what they were to learn.

All my books will retail at $22.00 each and with 50% off to dealers, you would make 100% clear profit, since you would sell direct. The students who bought every book would be those most aware of the state of the world. These would be the most likely candidates for a community defense group. These would also be the most likely to go from Jiu-Jitsu to the more lethal aspects of American Martial Arts, including improvised weaponry. (You would have to let your students learn improvised weaponry on their own, as that subject would put you on very shaky legal ground).

As time went by, you would find you had a ready-made group of like-thinking men and women. You wouldn't need a name for it or any clearcut philosophy or ideology. But as things got worse in your area you would have quite a large group of trained, natural gurillas to draw on. With them you could insure the community's internal security as well as a defense against outside antagonists.

IMPROVISED WEAPONRY AS A MARTIAL ART

From Taekwondo Times

The true Martial Artist is a danger only to the dangerous. With skill comes responsibility along with confidence. This adds up to a self-reliance which makes anyone with that discipline an asset to those around him.

But as one develops personal mastery, one anticipates a time when his services will be needed by the community. Then, as martial artists of old were called upon to defend their less-able brothers, he will need to know the arts of improvised weaponry.

Such knowledge is just an extension of his own body, as was the nunchaku (rice flail), etc. Tyranny cannot prevail where the martial artist protects.

Kurt Saxon's Poor Man's James Bond series is the most complete, and growing, collection of methods of improvised weaponry. No invader or home-grown despot can disarm a community or feel safe in an occupation.

Beyond The Poor Man's James Bond, the Survivor series teaches domestic self-reliance so

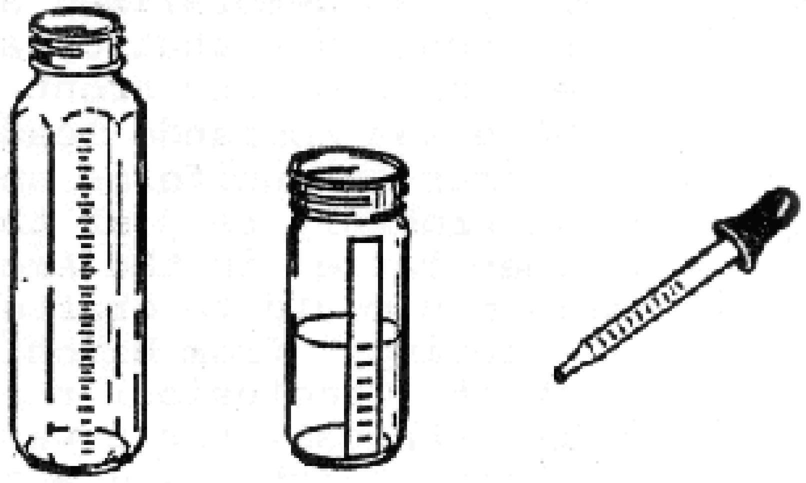
on the shelf when not in use and is much more efficient for glass work than the alcohol burner.

For a complete course in glass blowing, bending, etc. see GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY.

GRADUATE AND CHEMISTRY FLASK

A graduate is a container with marks to measure liquids. An excellent graduate, and also a flask is a baby bottle. It will take the heat from an alcohol burner so it can also be used as a large test tube. Fitted with the right sized stopper with one or two holes, it will have many uses.

A smaller graduate is a common medicine dropper and even better is a hypodermic syringe. The dropper can be bought at any pharmacy and if they have none with marks, you can put them on with a ruler and a felt pen.



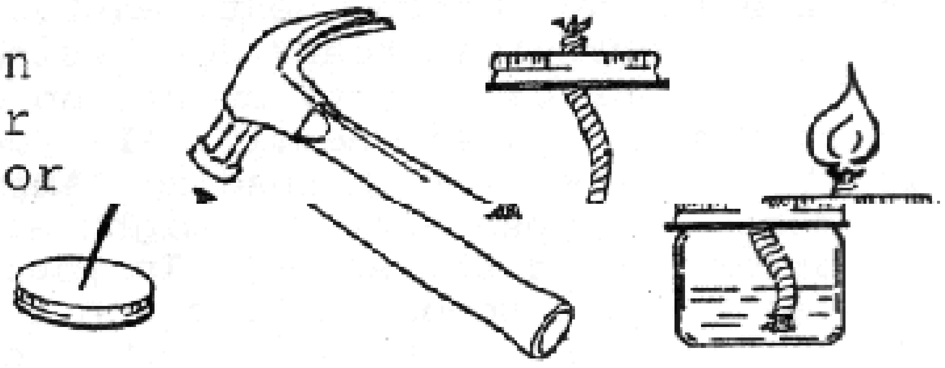
ALCOHOL BURNER

This is simple to make from a baby-food jar or any other of a chunky kind with a metal lid.

Punch a hole in the middle of the lid and work it wide enough to hold a four-inch length of cotton rope.

Rubbing alcohol, bought at any grocery or pharmacy is the safest fuel for such a lamp.

Fill the jar, tighten the lid and turn it upside down until the exposed part of the rope is saturated. Then turn it right-side up and light.



no one need starve or do without any of the necessities of life.

To combat stress, Mr. Saxon has even made a hypno-tape which guarantees clearness of mind and the banishment of worry. It enables the user to plumb his subconscious for buried answers to the problems that are holding him back from accomplishing his true potential.

All-in-all, Saxon's books and tapes are a positive reinforcement of the Martial Artist's striving for power over any threats to himself or his community.

MATCH HEAD BOMB

Simple safety match heads in a pipe, capped at both ends, make a devastating bomb. It is set off with a regular fuse.

A plastic Baggie is put into the pipe before the heads go in to prevent detonation by contact with the metal.

Cutting enough match heads to fill the pipe can be tedious work for one but an evening's fun for the family if you can drag them away from the TV.

NAPALM

About the best fire bomb is napalm. It has a thick consistancy, like jam, and is best for use on vehicles or buildings.

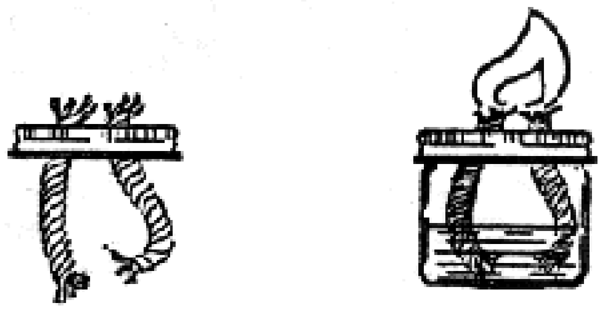
Napalm is simply one part gasoline and one part soap. The soap is either soap flakes or shredded bar soap. Detergents won't do.

The gasoline must be heated in order for the soap to melt. The usual way is with a double boiler where the top part has at least a two-quart capacity. The water in the bottom part is brought to a boil and the double boiler is taken from the stove and carried to where there is no flame.

Then one part, by volume, of gasoline is put in the top part and allowed to heat as much as it will and the soap is added and the mess is stirred until it thickens. A better way to heat the gasoline is to fill a bathtub with water as hot as you can get it. It will hold its heat longer and permit a much larger container than will the double boiler.

BROAD FLAME ALCOHOL BURNER

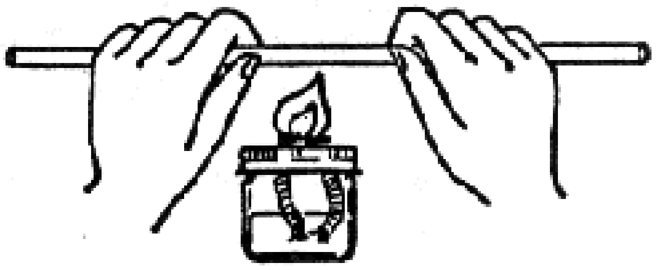
This one gives more heat over a wider area and is used mainly for glass work as it will enable you to bend glass into all kinds of odd shapes.

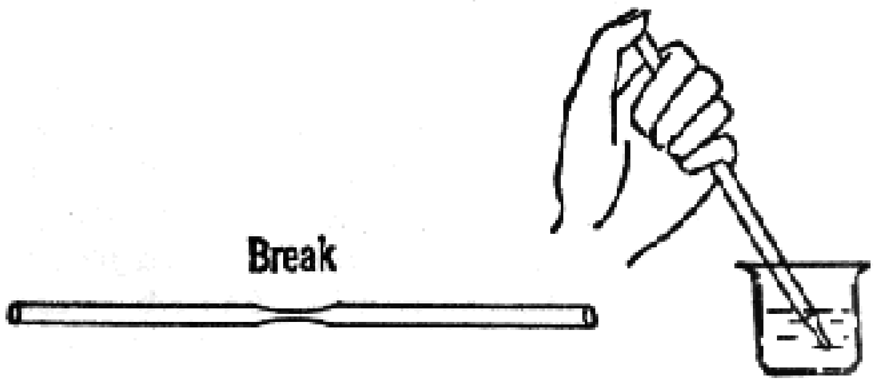


PIPETTE

With a pipette you can lift small organisms or flecks out of liquids. Also, you can pick up very small amounts of a liquid much easier than pouring. You might even mark the pipette for use as a measure.

To make pipettes, hold a length of glass tubing over the flame and, when it reddens all around, pull it gently at both ends until the middle is quite thin. Then break it in the middle.





To use it, put your thumb over the wide end and place the tip in the liquid directly over the particle you want. Then remove your thumb and the liquid will automatically rise and carry the particle with it.

MOUTH PIPETTE

The mouth pipette does much the same as the regular one but better. If you need a certain amount of what you're working with. You can suck up exactly as much as you need or can fill the pipette and, drop by drop, realease an exact amount into a process.

All you do to make it is to force the larger end of the

HOW I BOMBED ON THE DAVID LETTERMAN SHOW

By Kurt Saxon

A while back I was invited to be on the David Letterman show. The girl who called me said they had a copy of my book, "Granddad's Wonderful Book Of Chemistry" and thought it would make for an interesting subject. I thought so too and, as usual, I jumped to conclusions and suggested I could do some chemical magic. Actually, the copy they had was the early edition which didn't have "Chemical Magic" in it.

So, instead of going on the show and explaining the delights of being a mad scientist I volunteered to demonstrate. Never volunteer! Over the phone, the producer was quite excited about the project and urged me to do at least six demonstrations, as my segment would be from six to eight minutes.

I soon realized that maybe I had bitten off more than I could chew. I explained that I was experienced on talk shows but had never done any sort of performing. The producer encouraged me to do my best so I picked six examples I thought were simple and basic; spectacular but harmless.

One was nitrogen tri-iodide from page 150, XLII. Another was the ignition of potassium chlorate and sugar from page 153, XXXIV (i). Then came the spontaneous combustion of mercury, potassium and sodium; page 153, XLII.

Burning water came next; page 155, LVI. After that I meant to demonstrate lighting a cigarette with an ice cube; page 156, LXXIV. Last was simply how metallic sodium catches fire when wet.

At home I did all these projects with no trouble that I can remember. When I did them in rehearsal, a half hour before taping, everything went wrong. This was entirely my fault. I took everything for granted. Not having performed so before any audience, I didn't know enough to practice under stage conditions, even though the effects worked the first time.

I started setting up about three hours before I was to go on. First I mixed up a large, large, large batch of nitrogen tri-iodide. Better too much than too little, I thought, since the nitrogen tri-iodide would take an hour or more to dry. One of the stage hands had told me to make two batches so I could use one at rehearsal. I did and made even more than was in the first batch.

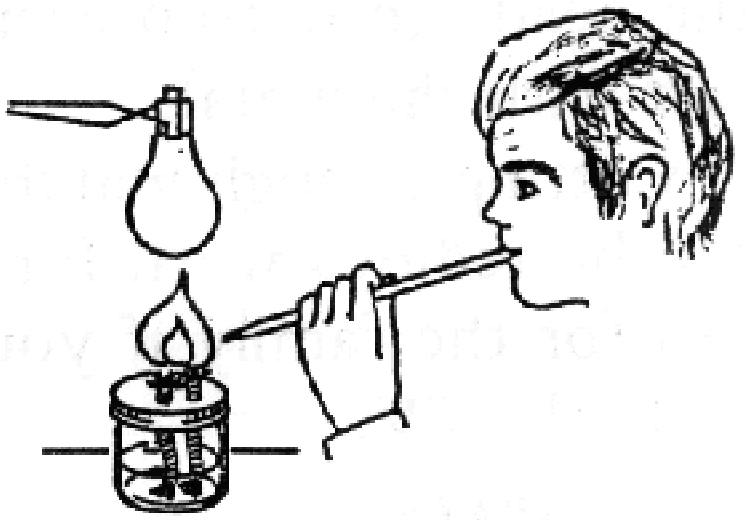
Rehearsal time came around and I put one board with the nitrogen tri-iodide on a tall, wheeled table and a stage hand moved it out in front of the cameras. I had everything lined up and began doing the various demonstrations and everything went wrong. First I put a slice of sodium in a pan and flooded it with water. It didn't burst into flame but just sputtered and gave off puffs of smoky mist. It had flamed at home, but not there. Why?

It occurred to me on the plane going home. When I first tried it I sliced off a piece of sodium and dropped it into some water. It did burst into flame. Another slice I'd laid aside just sputtered. I should have realized it at home when I first tried it. When sodium is first sliced, it is shiney and will ignite on contact with any moisture. However, it oxidizes almost

pipette into a foot of rubber or plastic tubing.

BLOWTORCH TYPE BURNER

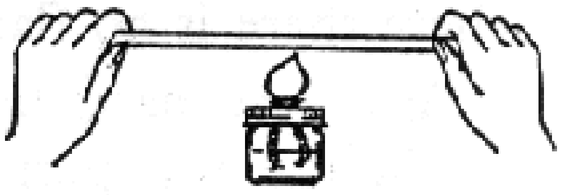
To turn your burner into a blowtorch, simply use the pipette to blow into the flame. This adds oxygen which makes the flame much hotter.

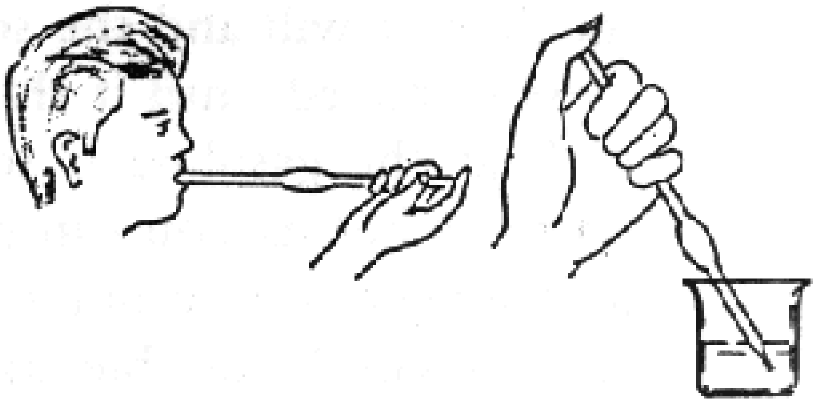


LARGE PIPETTE

This lets you gather larger amounts of liquid. Making it also shows you a simple principle of glass blowing which might encourage you to make even more complicated glassware.

Take a piece of glass tubing one foot or less and hold the middle over your broad flame or bunsen burner, turning until it glows red. Then put a finger over one end and blow into the other. The middle will bulge out over the length of the heated part. Try it. It's fun.





immediately, even as one watches, and becomes covered with a kind of whitish rust.

When put in the water at the studio, the oxidized sodium spluttered because of the insulating property of the oxide. As water penetrated the layer of sodium oxide it only created more oxide so no actual flaming occurred and it just spluttered.

The same oxidation prevented the cigarettes from being lit by the ice cube. When I was at home I tried the cigarette lighting trick in the kitchen because that was where the ice cubes were. I took one of my wife's cigarette butts from her ash tray by the sink and poked a space in the tobacco with a toothpick. I then put a fresh sliver of sodium in it and held an ice cube to its tip.

One drag and it was lit. This was because the cigarette was bone-dry and the sliver of sodium had no oxide coating. But when I prepared three fresh cigarettes on the set, none of them lit. Frustration. Of course, the fresh cigarettes were moist and so caused the oxide coating. The book suggested drying the cigarettes in the oven but I didn't pay attention.

Then there was the burning water trick. It worked at home because I had a large, glass petri dish with a fresh sliver of potassium in a layer of ether about an eigth of an inch thick. This kept the potassium from oxidizing. When I poured in some water, the ether stayed on top and the water ignited the potassium, which ignited the ether, producing a startling flame.

On the set, however, I had put the sliver of potassium down while doing something else and it had gotten a thin coating of oxide. Instead of the petri dish, I had a tin pie pan and used too little ether. So when pouring in the water, the oxide kept the potassium from igniting and it just spluttered and bubbled, pushing the too-thin layer of ether away.

I didn't get around to mixing the sodium, potassium and mercury. That would have worked but was not spectacular. What did me in was the potassium chlorate and sugar ignited by sulphuric acid. Nothing could go wrong with that but what it caused was something I hadn't anticipated.

I had put the board spread with about six square inches by one eigth of an inch of nitrogen tri-oxide about the middle of the table. Barry, one of the exutives, was leaning against the table with his left ear about two feet from the nitrogen tri-iodide. I didn't notice he was so close because I was preoccupied. When I did the on-camera performance I had intended to have David stand at least three feet back.

Anyway, after the failure of some of the most obvious demonstrations, like the igniting of the ether and lighting the cigarette with an ice cube I was worried that I wouldn't have any reason to be on the show. I believe it was this feeling of frustration which kept me from being aware of the consequences of carelessness. At any rate, instead of having Barry stand well away, as I would have had David, I didn't even notice he was so close to the nitrogen tri-iodide.

But I was not only feeling frustrated but being stupid, I remembered that dropping sulphuric acid on the small pile of potassium chlorate and sugar did ignite beautifully and send pretty sparks all over every time. Perhaps I felt I could show Barry I could get something to work after all.

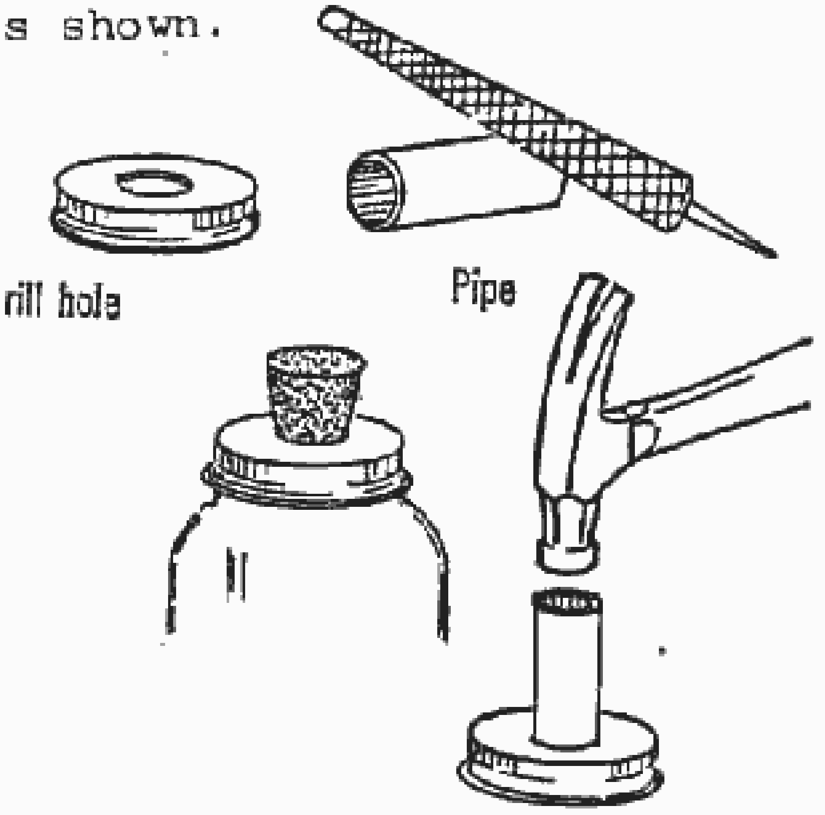
Then it happened. The potassium chlorate and sugar mixture did ignite beautifully and sent sparks everywhere, including into the large smear of nitrogen tri-iodide. What followed was not a bang but a boom. It sounded like nothing less than a bomb going off in the

MASON JAR CHEMISTRY FLASK

Mason jars are made of pyrex and so can be heated with an alcohol burner. They make very good large flasks. They come in quart, pint and half-pint sizes. They are also easier to clean than regular flasks.

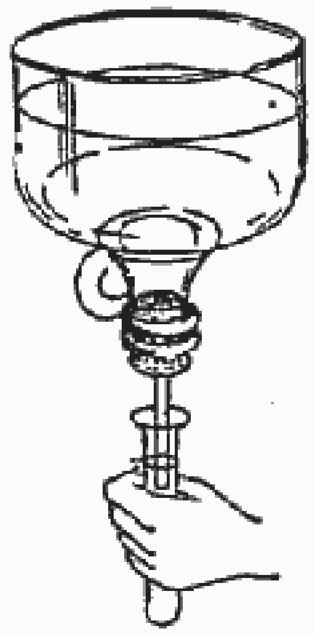
The lid for the flask can be either a two-part Mason jar lid or one from a mayonnaise jar. Make a stopper-sized hole in the top and make it from the top of the lid inward so the stopper will go in smoothly.

You can either drill a hole and enlarge it with tin snips and a file, or make a punch, or punches for different sized stoppers. Punches are made from short pieces of metal pipe 3/4 or 1 inch in diameter. The outside edge of the pipe is ground or filed so it is quite sharp. Then, with a bit of wood under the lid, the pipe is centered and hammered as shown.



FUNNEL

Plastic funnels of nearly any size can be bought at your supermarket. But you can also



studio and was heard all over that floor and the floors above and below.

Barry was understandably traumatized and in a state of shock. He skittered sideways away from the explosion and sat down on the edge of the stage. He then yelled, "Am I bleeding? I can't hear. Can I get this stuff out of my pants?"

He wasn't bleeding and his temporary deafness was to be expected under the circumstances. He was wearing white pants and there was nothing on them I could see. In a few minutes his hearing returned and he was out of shock and had suffered no injury. But I was truly sorry I had upset him so.

Naturally, David had heard the blast and refused to experience anything like it. I suggested to the producer that recounting the string of errors would make an amusing segment. But they were all too shook up to consider the subject so I was bumped.

If you watch talk shows on a regular basis you've heard many references to guests being scheduled but not being on the show. This happens quite often. It is usually because schedules are so tight and there is so much involved that they can't take any chances with a guest who might interfere with the show's even timing.

For weeks after, I was getting calls from readers all over the country who heard David mention me. Was I supposed to be on that show? Would I be on later? (They had watched every night after that). Anyway, I could only tell them that it was up to the producer to reschedule me and I was sure that chemical magic would not be the subject.

So take a lesson from my experience. When you do an experiment from GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY, follow it to the letter. Don't take anything for granted. And if you mean to perform before any audience do the thing at least six times first, rather than once at home and then bombing before your audience like I did.

What Is A Secret Agent?

by Kurt Saxon

A lot of my readers were confused by my Secret Agent concept. Since our country is terribly in need of Secret Agents, I'll separate fact from myth so you can see if you qualify.

You probably got your own impression of Secret Agents from the James Bond series, Patric McNee and Diana Rigg of "The Avengers" and Patrick McGoohan of "Secret Agent". These are the idealized Secret Agents and more in line with what a Secret Agent ought to be.

In actuality, however, the average Secret Agent is more like Don Adams in "Get Smart" or Inspector Clouseau of the "Pink Panther" series, played by the late Peter Sellers. In short, they are stupid and bungling.

The KGB isn't much better. The British Secret Agents are tops. The reason for this is that most of them are trained by the KGB. And since the British are more intelligent than the down-bred Russians, they know how to use their training. But the American Secret Agent is usually a paranoid clod, or traitor.

The FBI Agent isn't necessarily a "Secret" Agent. But he is so ineffective that he is usually a waste of the taxpayers' money. The secret is how he stays on the payroll. The reason for this is that the recruit has to be so Joe College, too straight and "normal". Thus, he can't identify with anti-establishment types to the degree it takes to learn what they're up to.

The ATF has the worst reputation among the weapons

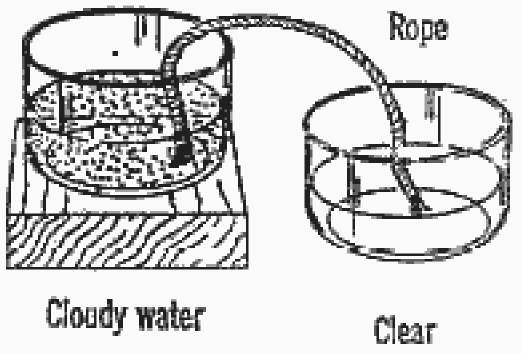
make your own in a pinch from the tops of glass or plastic bottles. A knife and scissors are all you need to work with plastic bottles but for glass, you'll need the nichrome wire bottle cutter.

A gallon jug top can be as big a funnel as you'll need. By using a stopper with glass or plastic tubing, it can be as small as you may want it.

An extra in making the funnel from glass is that the bottom part can be used as a lab bowl.

STRING FILTER

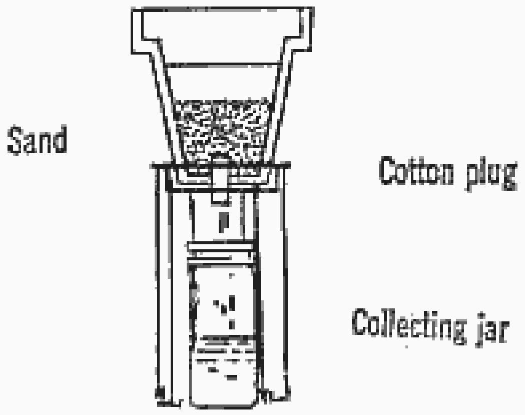
This is a clever way to filter a liquid without filter paper. All you need is a few inches of cotton rope, or even heavy twine, and two bowls. Place the bowls, one higher than the other, as shown. Then put the rope or twine in one bowl leading to the other and wait a few hours.



PLANT POT FILTER

For this you need a clay flower pot, some sand and a piece of cotton rope or rolled up cotton for a plug.

First put in the plug, then add a few inches of sand. The nice thing about the sand for filtering is that what you want left behindwill be held away from the plug by the sand and so will not clog the plug and stop the filtering action.



crowd but this is largely undeserved. For the most part they are intelligent and decent. But the excess zeal used by an occasional dingbat has given a good group a bad image. Also, they are greatly understaffed and so are generally innefective against the real criminal element.

But by far, the worst lot of "Secret" Agents is the CIA. Vice President Bush used to head the organization. When Reagan dies, if Bush runs the country like he did the CIA, the country's done for.

It took me only one run-in with the CIA to give up on them. When I perfected my Fang I decided to market them through the CIA. The idea was that if I made them and an Agent was caught in a foreign country, the weapon could not be traced to the government.

I called their headquarters in Langley, Virginia, (703-352-1100) and the phone was answered by a token darkey straight out of Central Casting. I told her I wanted to talk to someone in covert operations, or whatever they called that department. She told me I'd have to give her the name of someone in that department. It ought to have been obvious, even to that stupid bitch, that I didn't know any such name but I patiently told her to put me in touch with anyone handy.

A male darkey came on the line and I wondered if I'd called the NAACP by mistake. He had never heard of me and was impatient, as if he wanted to get back to his mop bucket. I told the idiot I wanted to send the agency a copy of THE POOR MAN'S JAMES BOND and THE WEAPONEER and a sample Fang with vaccine bottles of nicotine sulphate, potassium cyanide and ricin. When his room-temperature I.Q. grasped the idea that I was offering weapons for their Agents he snapped, "We don't kill people" and hung up.

Still hoping, I called an ATF Agent in Dallas and told him my problem in getting the real CIA to stand up. He gave me a number to call in Little Rock, (501-378-6181). I called and the phone was answered by a seemingly-concious woman who connected me with an Agent. This boob didn't want to give his full (or real) name but let me call him "Jim". I told him what I told the ATF Agent and he asked me if I wanted to join the CIA. Nothing in what I'd said was even a suggestion that I was looking for a job. I answered that I already had a job and just wanted to offer my services. As if he hadn't heard a word, he said he'd take my phone number and they'd get back to me if they needed me. To Hell with them.

Their most famous graduate, the bungling slob, G. Gordon Liddy was for a time, the prime example of a Secret Agent. He screwed up the Watergate break-in and was jailed for it.

More recently the CIA mined the harbor in Nicaragua, ineffectively. It simply damaged some of our allies' ships and America's reputation.

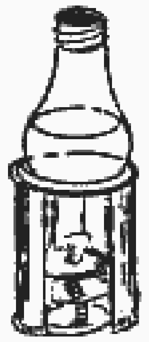
Secret Agents could do a lot to stop terrorism, especially by Moslem fanatics. I realize few of my subscribers are prepared to do big things at this time but I'll give a couple of examples of how real Secret Agents could squash terrorism, plus the traffic in dope.

The Moslem fanatics could be gotten to through their religion. Islam's most holy place is the Kaaba in Mecca. A secret agent in a private plane could simply swoop down and drop a pig on the Kaaba. To Moslims and Jews, the noble pig, food of Vikings, is unclean.

To drop a pig on the Kaaba would be the most blasphemous insult imaginable to Islam. On one of its legs

TRIPOD CANS

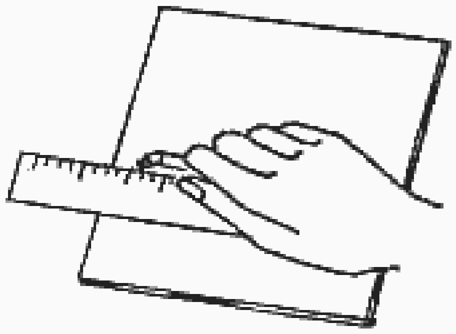
The purpose for these cans is to hold flasks or bottles away from the direct flame of your alcohol or bunsen burner. Collect a general assortment of different sized cans. Punch holes in the middle of the can bottoms. With tin snips or sharp scissors, enlarge the holes to accommodate your various sized flasks.

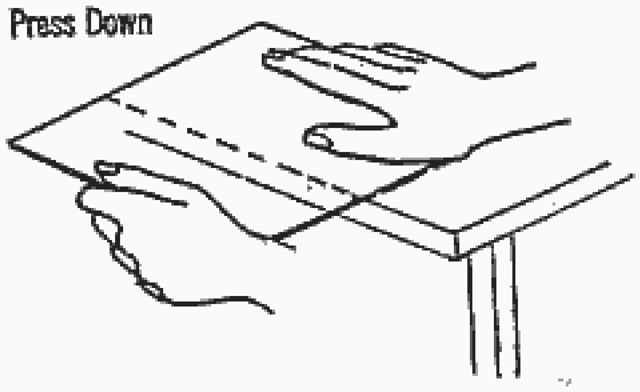


To make a tripod from a tin can, use the tin snips to cut strips from the open end down to the other end. You can cut three or even four strips out. The number doesn't matter as long as there is plenty of ventillation for the flame and strong support for the flask.

GLASS CUTTER

To cut microscope slides and glass for other lab equipment, lay the glass flat on some newspapers. With the ruler held firmly, run the glass cutter along a straight line. Then put the pane on the edge of the table with the wanted part jutting out over the table's edge. Now, simply snap the glass apart at the cut.





could be the message: "This is a pig. Release all American hostages, immediately. Any further actions against Americans will result in our return. And then we won't drop a pig".

The reaction would be outrage by every Moslem nation as you can well imagine. But the threat to their most holy place would force every Moslem to give up on even the slightest anti-American act. Even the most psychotic Moslem fanatic would realize that for him to cause the destruction of the Kaaba would keep him out of Pardise.

The dope traffic costs America billions of dollars each year. It also costs the lives and fortunes of thousands preyed on by muggers, burglars and doped-up psychotics. Of course, the whole dope problem could be resolved by legalizing drugs and letting the nation's inferiors blow their useless minds with no real loss to society. But this will not be done.

Even so, Secret Agents could intercept batches of heroin and cocain and lace it with ricin. Those who shot up or snorted the doctored dope would die. Depending on the area, Hollywood producers of the scummiest movies would go, inept politicians would make room for men and hopefully, a few Rock 'n Roll idols would bite the dust.

Nothing but positive results would come from poisoning illicit drugs. Aside from the initial elimination of some of the worst elements of society, only the suicidal would continue using.

Those two operations must be left to better equipped and financed Secret Agents. But you can think of many small ways you can act to preserve the best of our culture.

*

Secret Agents don't necessarily have to work alone. You may need help in training, even though you must not let even your closest friends in on certain personal activities. The "need to know" rule is a must for a Secret Agent.

Establish a reputation for something as far from your hobby as possible. Boast of your prowess in martial arts or underwater basket weaving. But don't express any interest in Secret Agenting to anyone you aren't trying to recruit, and then only if he is a very likely prospect.

Here I must warn you against joining any political activist groups. Such groups are always membered by the unstable and untrustworthy. I learned this in the sixties when I joined every right-wing group I could, except for the Klan. I drew the line there. A man who likes to dress well simply can't get those robes to drape properly.

Political groups are always either infiltrated or filled with big-mouths who are all talk. Anything done will be done by you and they'll turn you in simply for a pat on the head.

In the meantime, go to every gun show you can get to. There is the place to make contacts and to collect your arsenal.

While working on this, I was watching RED DAWN on TV. If you never plan on doing anything until the real RED DAWN hits us, you'll still have justified your existence.

At the beginning of the picture, a statue of Teddy Roosevelt was shown and his quote: "Far better it is to dare mighty things, than to rank with those poor, timid spirits who know neither victory nor defeat". There's your rationale for being a Secret Agent.

BOTTLE ETCHER

With a glass cutter bought cheaply at any hardware store, you can make cuts in bottles which are enough to cause them to break cleanly with the application of heat.

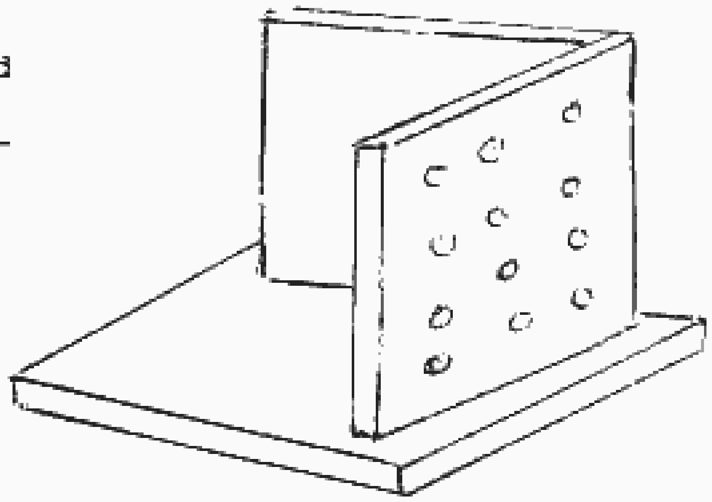
However, the break will be only as clean as the cut around the bottle is even. For this, you will need a form which will allow an even cut.

The best form is one which will allow you to cut any size bottle at the height you need to get the container you want.

The simple form described will do just that. With it you can cut petri dishes, bowls, funnels or anything else you may have a use for.

First, get two one inch by twelve inch boards and another to mount them on.

Drill about a dozen holes nearest to the size of the glass cutter. Mount the two boards in a broad V which will accommodate anything from a gallon bottle down to a pint.



Nail the boards firmly from the bottom.

To use, push the bottle as far into the V as it will go and insert the glass cutter in the hole nearest the height and diameter you want. Hold the glass cutter firmly to the bottle's side and turn the bottle a full circle, or two.

Now it is ready to heat and break.

BOTTLE CUTTER

This is a dandy tool which will enable you to cut bottles to any size.

First, make the simple stand shown. Then screw in two

THE MOLEHILL THAT ATE LOS ANGELES

I love smears by the press. As a former reporter I find it hilarious that "journalists" are so intimidated by THE POOR MAN'S JAMES BOND that they figuratively soil themselves when dealing with it. This latest is a classic and I want to share it with you.

Denise Hamilton of the Los Angeles Times called and questioned me on my lack of responsibility in publishing such dangerous material. What with such a high incidence of dementia in L.A. County, any suggestion of the lethal application of common substances must be done with criminal intent.

That seems to be the thrust of her article. She criticizes me for my callousness in publishing a three sentence description of oleander,(See top left of page 50). Then she elaborates on the oleander, its availability to L.A. dingbats, how it works, etc. According to her article anyone can poison anyone with little chance of being caught and the only reason the article's poisoner is being reinvestigated is that he had to boast about it. (Due to renewed interest I've reprinted the section on plant poisons).

She quotes my figure of 60,000 PMJBs sold nationwide over the past 17 years. While decrying such a spread of my work she gives no thought to the vast circulation of the L.A. Times, probably a million or more. So now several hundred thousand potential Borgias know just how to do it, far more than I could have reached.

L.A.'s favorite hunting sport, drive-by shootings, have killed scores so far this year. That's a problem for the game warden. But if they follow Denise's advice they might consider sending oleander-laced pizzas to their rivals instead of shooting them.

The whole article was born out of the alleged murder by poison of Tim (Belly) Waters, a Burbank coffin-stuffer, by David (Chuckles) Sconce. Chuckles, who along with his parents is charged with 67 counts of naughtiness, such as selling body parts of uncomplaining clients, clearly had the intention of depriving Belly of certain of his Constitutional Rights.

Chuckles borrowed an old edition of the PMJB from a friend as a guide to dealing with Belly. Poisons were the appropriate choice but, unless he was already familiar with oleander, the PMJB reference would have been inadaquate. I suppose he could have gotten the pertinent information from the library. He might also have called his local Poison Control office. A simple request for their booklet describing most household products to be kept out of the reach of children, as well as

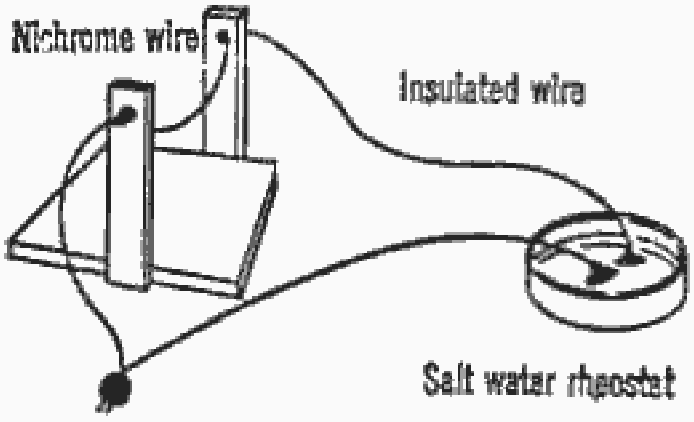
long screws so there is a space between the screw heads and the wood and with the ends of the screws projecting on the outsides of the wooden posts.

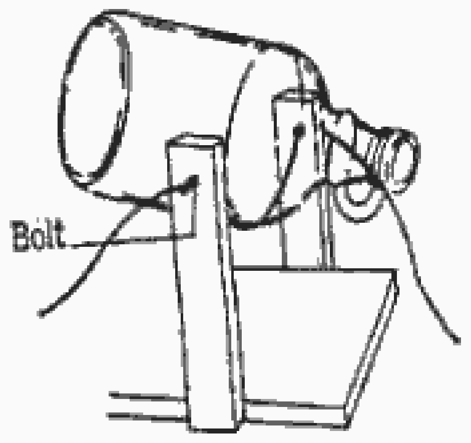
Next, take a six-foot extension cord and cut off the plug. Cut a couple of feet off one of the insulated wires and strip the insulation off an inch from both ends. Wrap one end around a projecting screw. Fit the other end to a small, lead fishing sinker.

Strip the insulation from an inch of the shorter wire and wrap that end around the other projecting screw.

Strip off an inch of insullat from the other wire and fix it to another small, lead fishing sinker.

Now for the nichrome wire. It usually comes coiled and is bought at the hardware store. Hold the coil and pull an end of the wire to straighten the length you want. Wind the ends around the two screw heads so it sags, as shown.





Put the two lead sinkers into a shallow, glass container. Don't let them touch or you will burn out the unit.

You now have a salt-water rheostat, minus the salt. Pure water is a poor conducter of electricity. But the gradual plants also dangerous to the young would have given him a much more detailed description of his sought-after weapon.

So Chuckles was hardly the impressionable dimwit so often pictured as being turned on by the PMJB.

Another fun thing about such smears is the "authorities" quoted in judging my material. They come out of the woodwork to tell how dangerous is the PMJB. Neil Livingstone expresses the Establishment hysteria regarding lethal knowledge in the hands of us just plain folks.

He pretends to despise my books yet he has not examined any. My books are not meant to teach anyone to do anything to anybody. They teach the making of weapons to use against aggression and future tyranny. He could not cite one case of any cop being hurt or any child blowing himself up because of the PMJB. When he says the PMJB is lacking proper safety procedures, he is as much as admitting he has never examined it. A cursory perusal of NEW IMPROVED PMJB gives clear warnings: Page 79, Flashpowder, 1st paragraph; Page 105, column 1, last paragraph; Page 140, all of INTRODUCTION; Page 195, column 1, bottom. Page 201, column 1, top. These are just a few I spotted by riffling through. Older editions are equally highlighted with warnings. Proper procedures, safety precautions and the accuracy of the formulas should be evident to any knowledgeable reader.

Livingstone no doubt styles himself as an ex-

Continued on next page

addition of salt will cause the water to bubble and this means it is conducting the electricity.

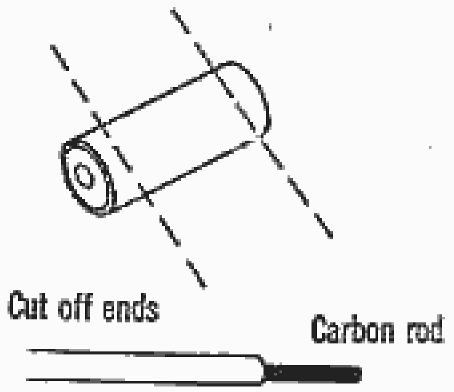
House current is much too strong for such a short length of nichrome wire or flashlight battery carbon rods. Without the rheostat, the insulated wire would melt or a fuse would be blown.

Now plug in to an outlet, add the salt until there are bubbles and watch the nichrome wire turn red.

Etch a line around the bottle with the etcher.

Hold your bottle so the etched part rests on the glowing wire and turn it slowly. The glass will begin to ping. The bottle should snap apart cleanly after one or two revolutions.

Smooth the edges by rubbing with emery paper.



CARBON ARC FURNACE

This simple carbon arc furnace produces a very high temperature at the tips of the carbon rods. It also produces a blinding light, so never look directly at it unless you are wearing very dark glasses.

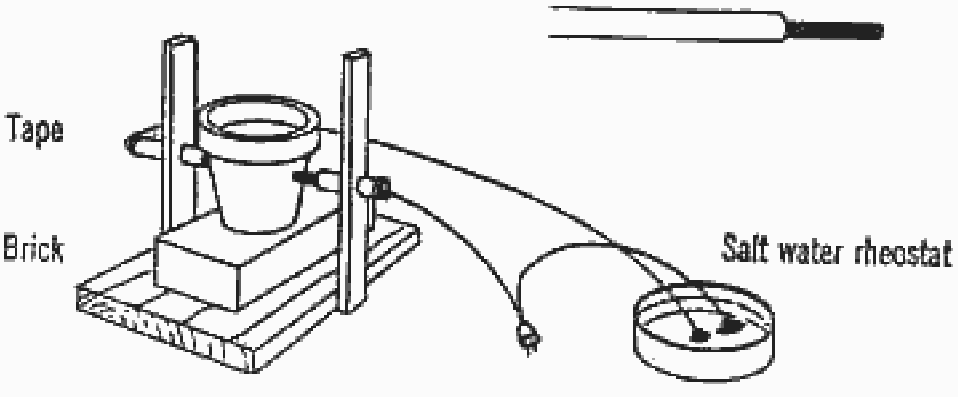
Cut two flashlight batteries at both ends until you get to their carbon rods. Clean off the rods and wrap an inch-wide strip of the metal cover of a battery tightly around one end of each rod.

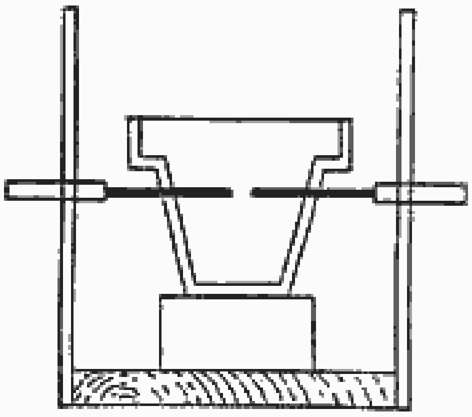
With a wooden frame, as shown, push the rods through holes drilled through both uprights, with the metal wrappings firmly in the holes, but with the rods loose enough to move back and forth.

Next, bore two holes into a small clay flowerpot with a drill or a screwdriver. Mount the pot on a brick and push the rods into the holes until they are about a quarter of an inch apart.

Connect the bare wires of the extension cord to the metal wrappings, held either by soldering or tape. Put in the plug and pour some salt into the bowl. Then slowly move the rods until they barely touch. At this point there should be a lot of sparks. (When pushing the electrified rods in or out use rubber-covered grip pliers). Pull them slowly apart so you will get an arc.

With a ceramic cover for your furnace you can generate enough heat to melt metals and do many other interesting things.





pert on terrorism, since he wrote a book on the subject. Such experts may boast of having read more newspaper articles on terrorism than most people but that's about as far as it goes in practice. Since I've done considerably more than read about terrorists I'll review his book, "The War Against Terrorism".

"Neil Livingstone's book is fatuous drivel from front to back. In describing the terrorist element as such effective attention-getters, Livingstone teaches the violent and mentally unstable how to hold the Establishment at bay and at the same time gain the prestige such losers could never hope for using their inferior abilities legitimately. He graphically illustrates the techniques of misfits to create destruction far out of proportion to their miniscule numbers. Any lonely and alienated individual has but to read "The War Against Terrorism" to put himself and a few equally bitter and twisted acquaintances on the path of "resistance on behalf of The People". This book is dangerous. I do not think the First Amendment ought to protect those who write books encouraging disturbed people to act out paranoid rage and murder fantasies. I want this book banned".

Of course, I've not read his book, but he didn't read mine either. So, there.

Such books, however, can provide rationales for acts of destruction and cruelty by dissidents. They also tend to provide the dissident with a picture of himself as part of an intellectual elite. Another book I've read but will not name, could almost serve as a terrorists' recruiter's manual with such plaudits as, "Yet the terrorist mystique has considerable attraction for alert, intelligent, capable individuals of all age groups in many countries".

San Diego County's own Conrad Greyson bemoans the fate of the six kids in his area blown up each year. He says, "we always find these manuals". He didn't name mine but I'll bet he would have if he did. But he seems to blame the damage on the manuals instead of the kids, or their apathetic parents.

I liked his account of "raiding" the house of a 17 year-old who blew himself up with homemade explosives. Conrad seems to blame Desert's IMPROVISED MUNITIONS BLACK BOOK.

But he was a young man, old enough to join the Marines, with permission. Nor would he have necessarily gotten the idea from the book. Most likely

Continued on next page

Claim of Poisoning Stirs Debate on 'Mayhem Manuals'

Los Angeles Times

Thursday, August 25, 1988

By DENISE HAMILTON, *Times Staff Writer*

Oleander is a familiar sight to Southern Californians. A dark green shrub with pink, red or white flowers, it brightens up freeway landscapes and sprouts gaily in suburban back yards.

What is not as well known is that every inch of this photogenic plant harbors a hard-to-detect and potentially fatal poison for which there is no sure antidote.

Kurt Saxon knows. He wrote about the lethal properties of oleander in a sinister 1971 book called "The Poor Man's James Bond." The self-published text, which law enforcement officials have long deplored, tells readers how to kill people, commit arson and build bombs.

Earlier this year, both the ancient plant and the atomic-age book came under new scrutiny after witnesses at a preliminary hearing testified that Pasadena funeral home operator David Sconce said he had poisoned Burbank mortician Timothy Waters.

Waters, 24, died April 8, 1985, at Camarillo's Pleasant Valley Hospital. Until May, when toxicological tests turned up traces of oleander in Waters' blood and tissue, it had been thought that the 300-pound mortician died of natural causes brought on by obesity.

The Ventura County district attorney's office is reviewing the new evidence but has not determined whether to charge the 32-year-old Sconce in Waters' death. Sconce is awaiting trial in Pasadena Superior Court along with his parents, Jerry and Laurieanne Lamb Sconce, on 67 felony and misdemeanor charges regarding the operation of Lamb Funeral Home in Pasadena.

The charges range from mutilating corpses to selling body parts. David Sconce also faces charges of soliciting the murders of his grandparents and of a deputy district attorney who was the prosecutor in the preliminary hearing. The Sconces have denied all the charges.

Quest for Information

Nonetheless, the revelation of death by poisoning sent coroners, prosecutors and police investigators scurrying to learn more about the 12 or so known cases of oleander poisoning and to obtain copies of "The Poor Man's James Bond," which is not widely available but is stocked in some survivalist shops.

he had a well-formed idea and bought the book as a step in implementing his idea. At any rate, the book was not at fault. Pipe bombs are commonly shown on TV and are moron-simple. A book could only serve to add such safety features as my idea to put a plastic baggie in the pipe with its top pressed around the threads to prevent premature explosion through friction. The instructions could not have been faulty or lacking in proper cautionary procedures. Hadn't he already made 10 of them? Most likely he just got bored and careless.

And shouldn't Conrad be grateful that the jerk finally goofed? What would have happened if he had actually used those bombs? Think about that, Conrad, buddy.

So I conclude with SOF's own Jim Graves who judged my civic-mindedness in experimenting with poisons on winos as "sick". Relatives of a murdered woman were awarded nine million dollars because of an obvious this-gun-for-hire ad run by SOF. I think Jim is a little late in recognizing what sick is.

20/20 BLOWS BOMB BOOKS REPORT

THE GUN RUNNER 1986

by Kurt Saxon

On March 27 20/20 aired a segment on "Terrorist manuals". One obvious purpose was to expose and discredit the sellers of books on homemade weaponry as de-facto terrorists and heartless profiteers. Another object was to show that such material is a clear and present danger to society. 20/20 failed miserably on both counts.

20/20 obviously spent a great deal of time researching the subject. But when the theme is weapons of any kind, their liberal bias renders them helpless in a frenzy of hysterical inferences and name-calling.

Their first target was THE ANARCHIST COOKBOOK, compiled by William Powell. With its emphasis on narcotics and Powell's anti-establishment propaganda, it was the nearest 20/20 ever got to a terrorist manual.

One interviewee was Morris Litwak of The Larder, 11106 Magnolia Blvd., N. Hollywood, CA 91601. His main line is survival products but he stocks books on weaponry for those who would protect their goods from improvident looters all survivalists will have to contend with.

An interesting part and an endorsement of such books, especially mine, was a trip to drug and hardware stores by a 20/20 employee. She had a shopping list of ordinary items to be used for making bombs. Explosives expert, Jack McGeorge, assured 20/20 that her purchases would make explosives equivalent to five or six sticks of dynamite.

They next spent 35 seconds on the nut who threatened to blow up the Washington Monument four years ago. Patrolman Jim Powell, first officer to examine the truck believed to have been filled with explosives, said of such manuals: "It is a detriment to us. It's a detriment to all law enforcement officers and the general public as well". But there were no explosives in the truck and the event had no tie-in to books of any sort.

During my interview they had the camera on me for about 30 minutes as I discussed many aspects of the weapons book field. They cut my part down to 90 seconds. I told them my

It also raised concerns that texts such as Saxon's could prove dangerous in the hands of violent, mentally unstable individuals and sparked debate on censorship vs. freedom of the press.

Neil Livingstone, a Georgetown University professor who wrote "The War Against Terrorism," called Saxon's book "an atrocious piece of literature that serves no public interest." He wants it banned.

"Kurt's books teach people how to kill cops and teach children how to blow themselves up," he added. "I don't think the First Amendment ought to protect you if you write a book on how to murder someone."

Law enforcement officials dub books such as Saxon's "mayhem manuals" and say they often find such texts when they raid illegal explosives labs, drug labs and terrorist hide-outs. Although it is difficult to tie violent incidents directly to the books, police psychologists say the manuals are dangerous because they encourage disturbed people to act out paranoid rage and murder fantasies.

Lt. Don Beasley, who heads the Los Angeles Police Department's explosives squad, says criminals often photocopy and pass around pages of "The Poor Man's James Bond" and "The Anarchist Cookbook," another such tome that was popular in the 1960s.

The police say danger also arises because the books occasionally print inaccurate chemical formulas or do not indicate proper safety procedures. Livingstone said this is especially true of "The Poor Man's James Bond."

"We get an average of six kids a year who blow themselves up, and when we get to their house, we always find these manuals," said San Diego County Sheriff's Sgt. Conrad Grayson of the bomb and arson squad.

Last year, the squad raided an Escondido house after a 17-year-old boy blew himself up with homemade explosives. Ten pipe bombs and a how-to text titled "Improvised Munitions Black Book" were found.

Even those most staunchly committed to press freedom and the public's right to bear arms recoil at some aspects of Saxon's book, which includes a chatty section on how to test homemade poison concoctions on homeless winos.

"That's pretty sick," said Jim Graves, managing editor of Soldier of Fortune, the guns-and-adventure magazine.

Saxon claims his book has sold 60,000 copies, many via mail order. Few mainstream bookstores stock "The Poor Man's James Bond"; some bookshop owners interviewed say they don't want it on main purpose for publishing THE POOR MAN'S JAMES BOND, THE WEAPONEER and my books on self-sufficiency was money.

Of course I write and compile for money. An author and/or compiler hasn't arrived until he can make a living from the sale of his work to a satisfied market. But since they were unable to show me up as a radical pamphleteer turning out terrorist propaganda after a hard day's work as a dish washer, they meant to project me as an irresponsible profiteer.

Reaching, as 20/20 did to justify Powell's statements, 20/20 wasted a full two minutes recounting the case of Texan, John Chanslor, who tried to buy ricin from Minnery in 1982. It was a lurid case, but again had nothing to do with weapons books. Had Chanslor bought my WEAPONEER, made his own ricin and killed his wife, there would have been some justification for airing the case in conjunction with "terrorist manuals".

In a letter John Minnery wrote to me in 1982 concerning Chanslor, he told me Chanslor had contacted him through his publisher. Obviously, Chanslor had read one or more of Minnery's books but the ricin process isn't there. So the Chanslor spot on 20/20 was irrelevant concerning Minnery's or any other such books.

Moving on, 20/20 said, "Robert McBrian has been helping to coordinate the Federal Government's fight against terrorism for almost 15 years (With little if any success, I might add). He's one of Washington's most knowledgeable experts".

McBrian told 20/20, "We've had bombers who've admitted they have used the manuals in concocting their devices. Some of the literature has been found in a variety of the American terrorist type groups.

"There was a raid last year on the stronghold of the CSA, an extreme right radical organization. The compound had various booby-traps, weapons, illegal and otherwise, lots of explosives and manuals on the premisis on how to use the explosives and how to make explosives".

Since I'm quite familiar with the now defunct CSA (see page 81 of THE GUN RUNNER), I know that this reference, too, was irrelevant. Over the years the CSA had several demolitions and weapons experts, trained by the military. They never really needed such manuals. So Ellison bombed a fag church and a pipeline of some sort, as I remember. Any of several of his members could have built the bombs without referring to any manual.

The film footage 20/20 showed on the CSA ordnance contained no improvised weaponry or manuals on the subject. A copy of the PMJB was shown on the original film but had been purchased only a couple of months before the raid and so had not been used.

The CSA was a cult which, over the years, had collected weapons and explosives with great zeal. They didn't get their knowledge of weapons, improvised or otherwise, from our books. So the CSA's antics are also irrelevant to the question of our manuals being a detriment to society.

McBrian continued: "Juveniles are learning from this sort of thing. A substantial number of explosives incidents that are investigated every year by Federal Agents and by local authorities involve accidents. Unfortunately, many of these accidents are by curiosity seekers and the interested juveniles who decide they are going to see if they can make themselves a bomb; see if they can make something go boom. And it's very tragic".

Tragic, yes. But what about parental supervision? And how many such tragedies happened to ignorant youngsters trying to recreate a bomb from a TV show as opposed to our books? Only the inference is there.

A few weeks previous to the airing of the "terrorist manual" segment, 20/20 did a piece on a psychotic doctor convicted of poisoning seven of his patients. He had also tried to kill his co-workers with iced tea laced with ant

their shelves.

'Russians and Martians'

"I'm torn two ways. It's a free speech issue on one hand and deplorable on the other," said Dosier Hammond, the former president of the Southern California Booksellers' Assn. and the trade-book manager at the UCLA student bookstore, which does not carry the book.

Saxon, a folksy 56-year-old who lives in Harrison, Ark., and publishes survivalist books says with glee that his book will come in handy "when the Russians and Martians invade."

Saxon has deleted the oleander poison entry in his "New Improved Poor Man's James Bond" because, he said, "it wasn't fanciful enough."

The section originally read: "Oleanders are common flowers but are about as poisonous as any plant. The heart is affected very quickly and severely. Both the branches and the leaves are lethal."

Experts say only a fraction of oleander poisonings, whether accidental or intentional homicides, are reported. Dr. Fredric Rieders, a forensic toxicologist with National Medical Services in Philadelphia, said children, in particular, are susceptible to oleander poisoning because they put things in their mouths.

Rieders said symptoms include vomiting, diarrhea, indigestion and a contracting of the heart until the muscle cramps cause the blood to stop flowing, which can result in death.

"Once the poisoning has occurred, it is extremely difficult to counteract it. It is mostly in God's hands," Rieders said.

A minuscule amount of the plant is enough to be fatal, experts said.

Dr. F. Warren Lovell, Ventura County's coroner, says he knows of two oleander poisoning cases—one in which a 96-year-old woman in Northern California committed suicide by eating oleander leaves and a case in which a Haitian herb doctor in Florida prescribed oleander tea for ailing patients and accidentally killed one.

Then there are the unconfirmed tales, such as the one about the Boy Scout who barbecued a wiener on an oleander branch and died.

Waters, who ran the Burbank-based Alpha Society, a cremation service, died in agony after two days of bloody vomiting and diarrhea at the Camarillo house of his mother, Mary Lou Waters. An autopsy performed by the Ventura, poison.

Copies of the PMJB and THE WEAPONEER were shown among his effects, along with various poisons. But he was a doctor, with the training and with easy access to many poisonous substances. I've never written about ant poison and the deaths of his seven victims were not described as a result of anything he had read in my books. But again, there were my books, there were some bodies, but no direct connection.

For such a prestigious program as 20/20 to raise an alarm about our "manuals for mayhem", "terrorist literature", etc., without one clearcut example is shameful. And if McBrian is such an expert and so close to the subject and so willing to collaborate with 20/20, why couldn't he have supplied them with at least one irrefutable example?

I've sold over 50,000 copies of the PMJB. Paladin published 300,000 weapons and related books last year alone, and with Loompanics, Delta, Desert, Alpha, etc.; millions over the years. On the surface, this should be alarming. But where are the body counts? Where are the examples of crimes which would not have been committed without such literature?

What with the hostility shown us by the media it would be reasonable to expect them to rub our noses in actual examples if they had them. A few years ago a man answered a classified ad in SOLDIER OF FORTUNE, became a mercenary, went to Africa and got captured and was executed. The media had a field day. "The man would be alive today except for SOLDIER OF FORTUNE", they all said. (The man was an adult and responsible for his actions. SOF was blameless).

Recently, SOF ran an ad by a man in an American prison who wanted to hire mercenaries to help him escape. The ad was answered and four or five mercenaries joined him in prison. Again, a media barrage of accusations against SOF.

So if Johnny, due to a lack of parental supervision, is found with his hands and face blown off and one of our manuals glued to the ceiling with his blood, can anyone doubt the media reaction? Or if tomorrow a terrorist begins throwing bombs he could not have made without one of our books, will not the media lay the blame at the publisher's door as they did with SOF?

Although we can't be expected to act as surrogate parents or public guardians anyway, 20/20 showed an extreme lack of professionalism and future credibility in accusing us of contributing to violence, using nothing but inference and innuendo. Where is the journalism of Joseph Pulitzer? Where are the objective investigative reporters?

The 20/20 staff sought to expose our field, hoping to find trails littered with the bodies of innocents leading to our firms. No bodies. They may have hoped to show a scroungy band of anti-social, murderous nihilists fomenting revolution and terrorism wherever they could. Instead, they found only well-educated, cleancut authors and publishers, unaffiliated with any radical groups and with not a terroristic aim among us.

You might wonder why the media so fears and hates us that they would strike out so blindly. I have a theory you might consider. For years, the liberal news media has been pushing their cameras into the faces of every violent mediocrity screaming, "Down with America!"

The media has consistently furthered the causes of the weak minded and destructive "disadvantaged" of every race, creed and color. They have encouraged the entry into our country of millions of illegal aliens; diseased, criminal, illiterate and perverse. Our streets are filled with savages who rape, rob, maim and kill, almost with impunity.

Having destroyed our republic and undermined their own democracy, they fear the violence and terrorism they themselves have nurtured. Yet, as the scorpion who stung to death the frog carrying him across the stream, because it was his nature, they follow their own natures still.

County Coroner's office said Waters died of natural causes, compounded by his extreme obesity and fatty deposits in his liver.

Some authorities today question that conclusion and say the coroner should have carried out toxicological tests.

"The autopsy looked real funny to me," said Walt Lewis, the deputy district attorney in Pasadena who initially handled the Sconce case, but was removed after Sconce was accused of soliciting his slaying.

"Here's a guy who's 24 and weighs 300 pounds, and he died of fatty deposits in the liver?" Lewis asked rhetorically.

Lovell, who became Ventura County's coroner in late 1985, said the previous coroner indicated he planned to perform toxicological tests. But Lovell said he left the post in July, 1985, without doing so.

Both Lovell and others point out that standard toxicological tests would not have turned up the presence of oleander, however, because it requires a specific test.

"If you don't suspect oleander, it would be way down on your list of things to look for," Rieders said.

It wasn't until this year that the authorities began to suspect foul play. During an 8-month hearing in Pasadena Superior Court, witnesses testified that Sconce hired two men to beat up Waters on Feb. 12, 1985.

David Edwards, a former Lamb employee, testified that Sconce borrowed the Saxon book to learn how to poison a neighbor's dog.

Witnesses said that in March Sconce went to a Simi Valley restaurant where Waters was eating and told witnesses that he dropped poison into Waters' mixed drink when he left the table.

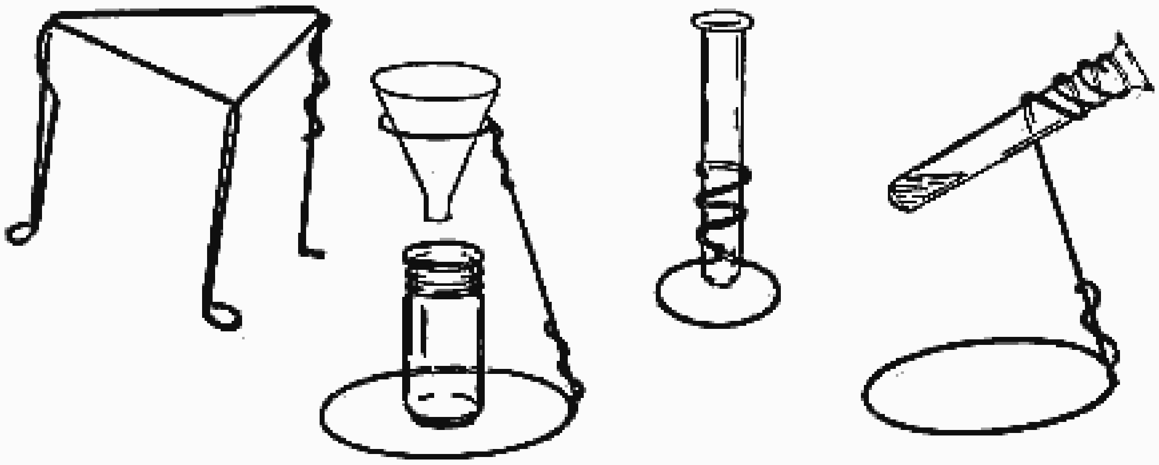
The motive, according to witnesses, was that Sconce wanted to silence Waters because the Burbank mortician suspected that Lamb Funeral Home was conducting illegal, multiple cremations.

One cellmate testified that the poison was not strong enough, so Sconce poisoned Waters again, causing a heart attack. Cellmates testified that Sconce bragged about poisoning Waters.

The Ventura County district attorney's office said it probably will not decide whether to file murder charges against Sconce until September, because the prosecutor reviewing the evidence is on vacation.

CLOTHES HANGER STANDS

A pair of needle-nosed pliers and a pair of regular pliers and a few clothes hangers will allow you to make ever so many different pieces of lab equipment, as shown.



PRUSSIC ACID

Prussic, or hydrocyanic, acid is one of the most poisonous compounds known. A student once described it as being so poisonous that a drop on the tongue of a dog is enough to kill a man. Nazis and Communists used to murder each other with it before Hitler came to power.

It is shot from a water pistol into the victim's face. The victim automatically gasps in surprise and droplets of the acid are drawn up the nose to the olfactory nerves. Before he realizes he has been attacked he is unconcious. Within three minutes of his collapse he is dead.

A few drops in the mouth is also fatal. So just consider that if a man is shot in the face with prussic acid he will drop dead before he can move ten feet.

The attacker usually hides the water pistol in a folded newspaper and shoots the victim in the face while passing him on the street or on a staircase. The victim stops in surprise and collapses and dies of an apparent heart attack. The attacker simply keeps on going and passersby gather to gawk and discuss their own coronaries. I think it would be great fun to watch what would happen to some poor son of a bitch who tried to give the victim mouth-to-mouth resuscitation.

Small batches of prussic acid are made with your still. The ingredients needed are 15 parts of potassium ferrocyanide, nine parts of distilled water, nine parts of strong sulfuric acid and five parts of calcium chloride. The calcium chloride can be bought or it can be made by covering broken up bits of blackboard chalk with hydrochloric acid and letting it soak in well and then drying it.

To start the process, put the potassium ferrocyanide into the flask first. Then put in the water and swirl the flask to mix both ingredients well. Next, the sulfuric acid is poured in, slowly, and the mess is well stirred with a glass rod or tube.

The calcium chloride, in coarse fragments, is put into the receiving bottle and a two hole stopper is put in with a tube leading outside.

Measurements are by weight. Consider the parts as ounces. Depending on the size batch you need, the measurements are cut in half until you reach the quantity you want. Below are four sample size batches starting with 15 parts, or ounces, and going down the scale to one and seven-eighths parts, or ounces. Measuring parts is easy once you get the hang of it.

SAMPLE BATCHES:	1	2	3	4
Potassium ferrocyanide	15 oz.	7½ oz.	3¾ oz.	1 7/8 oz.
Distilled water	9 oz.	4½ oz.	2¼ oz.	1 1/8 oz.
Sulfuric acid	9 oz.	4½ oz.	2¼ oz.	1 1/8 oz.
Calcium chloride	5 oz.	2½ oz.	1¼ oz.	5/8 oz.

If you lack a lab scale you can measure with plastic cups on a $3.00 postage scale bought at any office supply store. To do this, say you have a 500 ml flask and want the smallest batch, batch four.

You first put a plastic cup on the postage scale and turn the little knob that causes the scale to register no weight with the cup on it. You don't want to include the cup as part of the weight.

Then, while watching the scale, slowly pour the potassium ferrocyanide into the cup until the scale reads one and seven-eighths ounces or just a hair short of two ounces. Another cup is put on the scale and water is slowly poured in until it measures one and one-eighth ounces or just a hair over one ounce. The same goes for the sulfuric acid. Bits of calcium chloride are dropped into another cup until the scale reads five-eighths of an ounce or a hair over one-half ounce. The other batches are measured likewise.

A word of caution is in order concerning sulfuric acid. Never pour water into the acid as that would produce a violent reaction. Always pour the acid slowly into the water.

When you distill the mixture in the flask, watch closely to see that the stuff doesn't bubble up into the neck. If it boils up into the tube you'll have a real mess. If it starts to head for the neck of the flask, quickly remove the alcohol lamp. When the bubbles subside, return the lamp and continue to watch.

While this stuff is being made, wise Militants wear a cloth mask soaked in a brine solution of bicarbonate of soda. This goes over the nose and mouth.

When the distillate covers the calcium chloride in the receiving bottle the action is stopped and the apparatus is allowed to cool. Then the tubes are removed and the distillate is poured into another bottle with a good stopper. Light and air cause prussic acid to lose its potency quickly. Its container should be wrapped with aluminum foil and stored upside down in the refrigerator. A few drops of hydrochloric acid will help to preserve the prussic acid.

What is left in the flask is the most beautiful Prussian blue dye. Don't pour it down the sink where it will become a pollutant. Instead, use it to dye a shirt. This is yet another example of recycling.

If batch four is made, only about a half ounce of prussic acid is obtained. In a small water pistol this will be enough for several hits and will at least get you a seat on the bus.

Although deadly poison, prussic acid is only about as strong as vinegar and so leaves no burns on the skin. This is small consolation for the victim.

Prussic acid; Dick's, 1872

3947. Hydrocyanic Acid. This is also called *prussic acid*, and consists of a thin, colorless, and volatile liquid, having a strong odor of peach kernels. It boils at 79° Fahr. and solidifies at 45°; its specific gravity is .7058. It constitutes one of the most deadly poisons known. Its salts are HYDROCYANATES and METALLIC CYANIDES. Prussic acid, even when dilute, is very liable to spontaneous decomposition, and this speedily occurs when it is exposed to the light. To promote its preservation, it is usual to surround the bottles containing it with thick purple paper, and to keep them inverted in an obscure situation. The addition of a very small quantity of muriatic acid renders it much less liable to change, and is generally made by manufacturers for that purpose.

3948. To Obtain Anhydrous Prussic Acid. Pure crystallized ferrocyanide of potassium, 15 parts; water and sulphuric acid, of each 9 parts; distill in a glass retort into a well-cooled receiver, containing chloride of calcium in coarse fragments, 5 parts; stop the process as soon as the chloride in the receiver is perfectly covered by the distilled fluid, and decant the acid into a bottle furnished with a good stopper. Keep it in the dark, with the bottle inverted.

3949. Dilute Prussic Acid. Mix 41 grains muriatic acid with 1 fluid ounce distilled water, add 50¼ grains cyanide of silver, and shake together in a well stopped phial. When the precipitate has subsided, pour off the clear dilute acid and keep for use. (*See No.* 3947.) (*U. S. Ph.*)

3950. Tests for the Presence of Prussic Acid. It is distinguished by a strong odor of bitter almonds.

Neutralized by potash, and tested with a solution of sulphate or tincture of iron, it gives a blue precipitate, or one turning blue on the addition of dilute sulphuric or muriatic acid. This test may be applied by spreading a single drop of solution of potassa over the bottom of a white saucer or porcelain capsule, and inverting it over another vessel of the same size containing the matter under examination. After 2 to 5 minutes remove the upper capsule; add to the potassa upon it, a single drop of a solution of sulphate or tincture of iron, and expose it to the air for a few seconds. Next add 1 or 2 drops of dilute sulphuric acid, when a blue color will be developed if hydrocyanic acid is present in the matter tested.

Nitrate of silver gives a white clotty precipitate, soluble in boiling nitric acid; and which, when dried and heated in a test tube, evolves fumes of cyanogen, which burn with a violet or bluish colored flame. A watch glass, moistened with this test and inverted over matter containing hydrocyanic acid, becomes opaque and white from the formation of cyanide of silver.

Liebig's test is considered the most delicate. Moisten a watch-glass or porcelain capsule with 1 or 2 drops of yellow hydrosulphuret of ammonia; invert it over the matter as before, and after a few minutes dry it with a gentle heat. A glass rod dipped in a solution of a persalt or sesquisalt of iron, drawn over the glass, will form a blood-red streak if the smallest quantity of hydrocyanic acid is present.

3951. Test for the Strength of Prussic Acid. For estimating the strength of the commercial acid the following plan, proposed by Dr. Ure, will be found very exact and convenient. To 100 grains, or any other convenient quantity of the acid contained in a small phial, add in succession, small quantities of the peroxide of mercury in fine powder, till it ceases to be dissolved on agitation. The weight of the red precipitate taken up being divided by 4, gives a quotient representing the quantity of real prussic acid present. By weighing out beforehand, on a piece of paper or a watch-glass, 40 or 50 grains

of the peroxide, the residual weight of it shows at once the quantity expended. The operation may be always completed in five minutes, for the red precipitate dissolves as rapidly in the dilute prussic acid, with the aid of slight agitation, as sugar dissolves in water. Should the presence of muriatic acid be suspected, then the difference in the volatility of prussiate and muriate of ammonia may be had recourse to with advantage; the former exhaling at a very gentle heat, the latter requiring a subliming temperature of about 300° Fahr. After adding ammonia in slight excess to the prussic acid, if we evaporate to dryness at a heat of 212°, we may infer from the residuary sal-ammoniac the quantity of muriatic acid present. Every grain of sal-ammoniac corresponds to .6822 grains of muriatic acid.

Encyclopedia Britannica, 1892

PRUSSIC ACID, the familiar name for a dangerously poisonous, though chemically feeble, acid, known scientifically as "hydrocyanic acid," or "cyanide of hydrogen," is here taken as a convenient heading under which to treat of cyanides generally. This generic term (from κύανος, blue) is not meant to hint at any generic property; it is due simply to the fact that all cyanides, in an historical sense, are derivatives of a blue pigment which was discovered accidentally by Diesbach, a Berlin colourmaker, about the beginning of the 18th century.

The foundations of our present knowledge of cyanides were laid by Scheele (1783), whose discoveries were subsequently (from 1811) confirmed and supplemented, chiefly in the sense of quantitative determinations, by Gay-Lussac. Although we have no space for further historical notes, we must not omit to state that Gay-Lussac, as one result of his work, conceived and introduced into chemistry the notion of the "compound radical," having shown that prussic acid and its salts are related to the group NC in precisely the same way as chlorides are to chlorine, or sulphides to sulphur. This idea, in his own eyes and in those of his contemporaries, was greatly fortified by his success in even isolating his "cyanogène" as a substance.

In preparing cyanogen or cyanides in the laboratory the operator now always starts from prussiate of potash, with which, accordingly, we begin.

Prussiate of Potash, $(NC)_6Fe.K_4+3H_2O$ (syn. ferrocyanide of potassium; Germ. *Blutlaugensalz*).—This salt is being produced industrially from animal refuse (hide and horn clippings, old shoes, blood solids, &c.), carbonate of potash, and iron filings or borings as raw materials. The carbonate of potash is fused at a red heat in an iron pear-shaped vessel suspended within a furnace, or on the cupel-shaped sole of a reverberatory furnace, and the animal matter, which should be as dry as possible, is then introduced in instalments along with the iron. The fusion is continued as long as inflammable gases are going off; then the still fluid mass is ladled out and allowed to cool, when it hardens into a black stone-like body known to the manufacturer as "metal." When the broken-up metal is digested with water in an iron vessel prussiate of potash passes into solution, while a black residue of charcoal, metallic iron, sulphide of iron, &c., remains. The clarified solution, after sufficient concentration in the heat, deposits on cooling part of its prussiate in lemon-yellow quadratic crystals (generally truncated octahedra), which are purified by recrystallization. The last mother-liquors furnish an impure green salt, which is added to a fresh fuse and so utilized.

In former times it was believed that the prussiate was produced during the fusion process, and in the subsequent process of lixiviation simply passed into solution, until Liebig showed that this view was untenable. The fuse cannot contain ready-formed prussiate, because this salt at a red heat breaks up with formation of a residue of carbide of iron and cyanide of potassium. The metal in fact when treated with dilute alcohol gives up to it plain cyanide of potassium, and the fully exhausted residue yields no prussiate on treatment with water. The prussiate accordingly must be produced during the process of lixiviation by the action of the cyanide of potassium on some ferrous compound in the metal. Liebig thought that it was partly the metallic iron, partly the sulphide of iron present in the metal, which effected the conversion. According to more recent researches a double sulphide, $K_2S+Fe_2S_3$, which is always produced during the fusion (from the reagents proper and the sulphur of the organic matter and that of the sulphate of potash present in the carbonate as an impurity), plays this important part. The double sulphide by the action of water breaks up into alkaline sulphide, sulphide of iron (FeS), and sulphur. This sulphide of iron is of a peculiar kind; it does what *ordinary* FeS does not effect, readily at least: it converts the cyanide into prussiate, thus, $6NC.K+FeS=K_2S+(NC)_6Fe.K_4$, while the eliminated sulphur of the original Fe_2S_3 unites with another part of the cyanide of potassium into sulphocyanate, $S+NCK=SNC.K$, which latter salt is thus unavoidably produced as a (rather inconvenient) bye-product. Pure prussiate of potash has the specific gravity 1·88; it is permanent in the air. It loses its water, part at 60° C., the rest at 100° C., but very slowly. The anhydrous salt is a white powder. The crystals dissolve in four parts of cold and in two parts of boiling water. It is insoluble in, and not dehydrated by, alcohol.

Prussiate of potash has the composition of a double salt, $Fe(NC)_2+4KNC$, but the idea that it contains these two binary cyanides is entirely at variance with its reactions. Cyanide of potassium is readily decomposed by even the feeblest acids, and to some extent even by water, with elimination of hydrocyanic acid, and on this account perhaps is intensely poisonous. A solution of the prussiate remains absolutely unchanged on evaporation, and the action on it even of strong acids in the cold results in the formation of the hydrogen salt, $(NC)_6FeH_4$, which is decomposed, it is true, but only when the mixture is heated, with evolution of hydrocyanic acid. It is not poisonous. Its solution when mixed with nitrate of silver does not give a precipitate of cyanide of silver, NC.Ag, and a solution of the two nitrates; but yields a unitary precipitate of the composition $(NC)_6Fe.Ag_4$, which contains all the iron; only nitrate of potassium passes into solution. Other heavy metallic salts behave similarly. On the strength of these considerations chemists, following the lead of Liebig, view prussiate as a binary compound of potassium, K_4, with a complex radical, N_6C_6Fe, "ferrocyanogen."

Hydrocyanic Acid, NC.H.—This acid is prepared most conveniently from prussiate of potash. Wöhler recommends the following method. Ten parts of powdered prussiate are placed in a retort, the neck of which is turned upwards, and a (cooled down) mixture of seven parts of oil of vitriol and fourteen parts of water is then added. If the aqueous acid is wanted, the exit-end of the retort is joined on direct to a Liebig's condenser, which must be kept very cool by a current of cold water. If the anhydrous acid is desired, two wide-necked bottles (or two large U-tubes) charged with fused chloride of calcium and kept at 30° C. by immersion in a water bath of this temperature, must be inserted between the retort and condenser. In this case more particularly it is indispensable to provide for a most efficient condensation of the vapours; the exit-end of the condenser should be provided with an adapter going down to near the bottom of the receiver, which must be surrounded by a freezing mixture. The temperature of the latter, of course, must not be allowed to fall to the freezing-point of the distillate. The retort is heated by means of a sand bath and a brisk distillation maintained until the residue begins to dry up. The result of the reaction is in accordance with the assumption that the dilute vitriol, in the first instance, converts the prussiate, one-half into $(NC)_6Fe.H_4$, the other into $(NC)_6Fe.K_2H_2$, and that through the effect of the heat these two bodies decompose each other into $\{(NC)_6Fe\}K_2Fe$, which remains in the residue as a precipitate, and $(NC)_6H_6=6NCH$, which distils over. Real NCH is a colourless liquid of 0·6967 specific gravity at 18° C., which freezes at −15° C. (Gay-Lussac) into a white fibrous solid. According to Schulz the acid, if really pure, remains liquid at −37° C. It boils at 26°·5 C.; at 4°·5 its vapour-tension already amounts to half an atmosphere. The vapour is inflammable and burns into carbonic acid, water, and nitrogen. The acid mixes with water in all proportions, with contraction and yet absorption of heat. The solution behaves on distillation like a mere mechanical mixture of its two components. Prussic acid has a very peculiar powerful smell; more characteristic still is a kind of choking action which even the highly attenuated vapour exerts on the larynx. Prussic acid is fearfully poisonous; a few drops of even the ordinary pharmaceutical preparation (of 2 per cent.) are sufficient to kill a large dog. It acts with characteristic promptitude, especially when inhaled as a vapour. Even a relatively large dose, if it has once found its way into the stomach without producing a fatal effect, is said to do relatively little harm there.[1]

Prussic acid is characteristically prone to suffer "spontaneous decomposition." Whether the *pure* anhydrous acid really is, in the strictest sense of the word, still requires to be found out; the ordinary preparation, when kept in a close bottle, soon turns brown and turbid from "azulmic" acid, a substance of complex constitution. Other things are formed at the same time. The *pure* aqueous acid is liable to similar changes; in its case formiate of ammonia always forms the predominant product. This change is easily understood—

$$\mathrm{NC.H} + 2\mathrm{H_2O} = \underset{\text{Ammonia.}}{\mathrm{NH_3}} + \underset{\text{Formic acid.}}{\mathrm{H.COOH}}.$$

A strong aqueous prussic acid, when mixed with fuming hydrochloric acid, is soon converted into a magma of crystals of salammoniac, with formation of formic acid, which remains dissolved. And yet, most singularly, the addition to the preparation of a small proportion of hydrochloric or sulphuric acid is the best means for preventing, or at least greatly retarding, its spontaneous change in the very same direction. Aqueous prussic acid acts only very feebly (if at all) on blue litmus; it combines with aqueous caustic alkalis but does not decompose their carbonates; nor does it act upon the generality of insoluble basic metallic oxides or hydrates; mercuric oxide and oxide of silver form noteworthy exceptions to this rule.

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[1] The *British Pharmacopœia* prescribes for the medicinal acid a strength of 2 per cent. of real NCH. The two medicinal preparations known as *aqua amygdalarum amararum* and as *aqua laurocerasi* respectively contain prussic acid in combination with hydride of benzoyl, $\mathrm{C_6H_5.COH}$. In neither case does the prussic acid pre-exist in the vegetable materials, but is produced during the mashing process which precedes the distillation, by a fermentative decomposition of the amygdalin which they contain.

LAUGHING GAS

Ammonium Nitrate
See Page 104

Laughing gas was one of the earliest anaesthetics. After a little while of inhaling the gas the patient became so happy he couldn't keep from laughing. Finally he would drift off to a pleasant sleep.

Some do-it-yourselfers have died while taking laughing gas. This is because they had generated it through plastic bags while their heads were inside. They were simply suffocating but were too bombed out to realize it.

The trick is to have a plastic clothes bag in which you generate a lot of the gas.Then you stop generating the gas and hold a small opening of the bag under your nose, getting plenty of oxygen in the meantime. Then, Whee!

To make it you start with ammonium nitrate bought from a chemical supply house or which you have purified with 100% rubbing or wood alcohol.

First, dissolve a quantity of ammonium nitrate in some water. Then you evaporate the water over the stove, while stirring, until you have a heavy brine. When nearly all the moisture is out it should solidify instantly when a drop is put on an ice cold metal plate.

When ready, dump it all out on a very cold surface. After a while, break it up and store it in a bottle.

A spoonful is put into a flask with a one-hole stopper, with a tube leading into a big plastic bag. The flask is heated with an alcohol lamp.

When the temperature in the flask reaches 480 F the gas will generate. If white fumes appear the heat should be lowered as the stuff explodes at 600 F.

When the bag is filled, stop the action and get ready to turn on.

Dick's, 1872

4060. Protoxide of Nitrogen. This gas is also called *nitrous oxide*, and is largely used by inhalation, under the name of *laughing gas*, to produce insensibility to pain. It is colorless, possesses an agreeable odor, and a sweetish taste. At 45° Fahr., and under a pressure of 50 atmospheres, it is liquid. Its specific gravity is 1.5241; it supports combustion, and is absorbed by water. Its most remarkable property is its action on the system when inspired. A few deep inspirations are usually succeeded by a pleasing state of excitement, and a strong propensity to laughter and muscular exertion, which soon subside, without being followed by languor or depression. Its effects, however, vary with different constitutions.

4061. To Prepare Laughing Gas. Evaporate a solution of nitrate of ammonia until a drop of the fused mass placed on a cold plate instantly solidifies; cool, break the lump into pieces, and place it in a stoppered bottle. For use, a portion is introduced into a glass retort, and heat applied by means of a spirit lamp. As soon as the heat reaches 480° Fahr., protoxide of nitrogen is evolved, and may be collected in bladders, gas bags, a gasometer, or in the pneumatic trough over warm water. (*See No.* 4031.) Should white fumes appear within the retort after the evolution of the gas has commenced, the heat should be lowered, as, when heated to about 600°, nitrate of ammonia explodes with violence. Nitrous oxide may also be made in the same way from crystallized nitrate of ammonia, or by exposing nitric oxide for some days over iron filings, but it requires great care in its preparation.

4062. Test for Pure Laughing Gas. When pure, it is colorless, has an agreeable odor, and does not affect a solution of nitrate of silver.

Sollmann's Manual of Pharmacology, 1917

NITROUS OXID

General Statement.—Nitrous oxid, N_2O, nitrogen monoxid or protoxid, "Laughing Gas," was the first of the inhalation anesthetics and is still the safest. When inhaled undiluted, it produces very rapidly unconsciousness and anesthesia, partly by a direct narcotic action, and partly by exclusion of oxygen. The asphyxia limits its use to very short operations, such as the extraction of teeth. It has the advantages of prompt action and recovery, absence of irritation and of after-effects, and is practically devoid of danger. By the addition of oxygen, the asphyxial factor may be removed. The anesthesia also becomes slower and lighter; but by carefully adjusting the percentage of oxygen (5 to 10 per cent.), a satisfactory degree of surgical anesthesia can be maintained for long periods, without letting the asphyxia obtain dangerous proportions. Nitrous oxid is especially valuable in the "Gas-Ether Sequence," by avoiding the unpleasant features of the induction of ether anesthesia.

Inhalation of Undiluted N_2O.—For short operations, as in dentistry, the gas is administered through a tight-fitting mask, so that all air is excluded. The symptoms run a very rapid course: the *preliminary effects* consist in a sweetish taste; numbness; exhilaration (laughter); confusion; deeper and quicker respiration; and fuller pulse. *Partial anesthesia*, with loss of consciousness, ensues in twenty to thirty seconds. The patient is subject to dreams and the anesthesia is imperfect. The reflexes are preserved and excitement may be present, especially if the patient is disturbed. The respiration is still regular, deep and quickened; the pulse full and rapid; the pupils enlarged; the face dusky, livid or pallid; the eyelids twitching and slightly separated. *Complete anesthesia* occurs in fifty to one hundred and twenty seconds, averaging fifty-six. Its onset is denoted by a change in the respiration, which becomes slightly irregular and noisy. The pulse is quickened by about 30 per cent. and is small. The blood pressure shows a large asphyxial rise (Kemp, 1897). The vasoconstriction diminishes the urine flow. The limbs are relaxed, but individual muscles exhibit clonic or epileptiform contractions. The pupils are almost invariably dilated. The face is cyanosed. Relaxation of the sphincters occurs rarely.

Operative Period.—As soon as this stage is reached, the gas is removed. The pulse at once becomes slower and fuller; the respiration also recovers rapidly; and the asphyxial symptoms disappear. The anesthesia lasts some twenty-two to thirty seconds after the gas is removed; and it is during this period that the operation must be performed. The total time between the beginning of the administration and complete recovery is therefore one hundred to one hundred and twenty seconds. The duration of the after-anesthesia increases with the duration of the administration. This may be prolonged to several minutes by giving the patient an occasional breath of pure air (every fifth inhalation); or by admitting a little air into the mask. The admission of air, however, makes the anesthesia uneven and unsatisfactory.

After-effects are generally absent with short administrations. Sometimes the patients complain of giddiness, headache, lassitude and drowsiness. Nausea is exceptional.

Accidents.—With short administrations, these are very rare, because of the wide margin between the first danger sign (noisy and irregular respiration) and death. Only about seventeen deaths have been reported, making the fatality less than 1 in 5,000,000.

KNOCKOUT DROPS

The first process for making chloral hydrate (knockout drops) is from Dick's formulary, 1872.

4276. Chloral. Chloral is an oily liquid, possessing an ethereal smell; it is soluble in alcohol, ether, and water, but its solution in the latter rapidly changes into a semi-solid crystalline mass of *hydrate* of *chloral*, soluble in a larger quantity of water. Chloral boils at 202°, and has a specific gravity of 1.502.

4277. To Obtain Chloral. Place anhydrous alcohol in a tubulated retort, and pass dry chlorine gas through it, at first in the cold, but afterwards with the application of a gentle heat. As soon as the chlorine passes undecomposed through the liquor at the boiling temperature, the process is complete. On cooling, the liquid in the retort solidifies, forming a crystalline mass of hydrated chloral. This must be melted by gentle heat, and agitated with thrice its volume of oil of vitriol, when, on increasing the heat a little, an oily stratum of impure chloral will rise to the surface. This must be removed, boiled for some time, to drive off some free hydrochloric acid and alcohol, and next distilled with an equal volume of oil of vitriol; lastly, it must be rectified from finely-powdered quicklime, stopping the process as soon as the surface of the lime becomes dry. The chlorine is best introduced by a tube inserted into the tubulature of the retort, and a long tube, bent upwards, should be connected with the beak to convey away the hydrochloric acid gas extricated, and to allow the volatilized alcohol and chloral to condense and flow back into the retort.

Knockout drops are usually given to someone when he is a little drunk. After fifteen minutes he is out for the night.

Chloral hydrate was used as a sedative in a dose of 0.6 gram. It is seldom used now and is hard to get. For those who know chemistry and would like to make it I include the formula.

The chemicals needed are bleach, Sani-Flush, ethyl alcohol, sulfuric acid and calcium oxide.

You will need pure alcohol so buy a fifth of 100 proof vodka. This is 50% alcohol so distill it off and you should have just a little over 12 ounces.

The equipment needed is the still, the chlorine bottle, some pieces of glass tubing, rubber tubing, a 600 ml beaker, a water glass, an aquarium aerator and a basting syringe and a cooking thermometer, both from the dime store.

A piece of glass tubing is fitted into the bottom of the stopper for the flask. To it is fitted an eight-inch length of rubber tubing and at the end of this is the aerator. Two more pieces of glass tubing are put into the top of the stopper and the rest of the equipment is set up as illustrated.

To begin, put 12 ounces of alcohol in the flask. Put two inches of bleach and a teaspoonfull of Sani-Flush in the chlorine bottle.

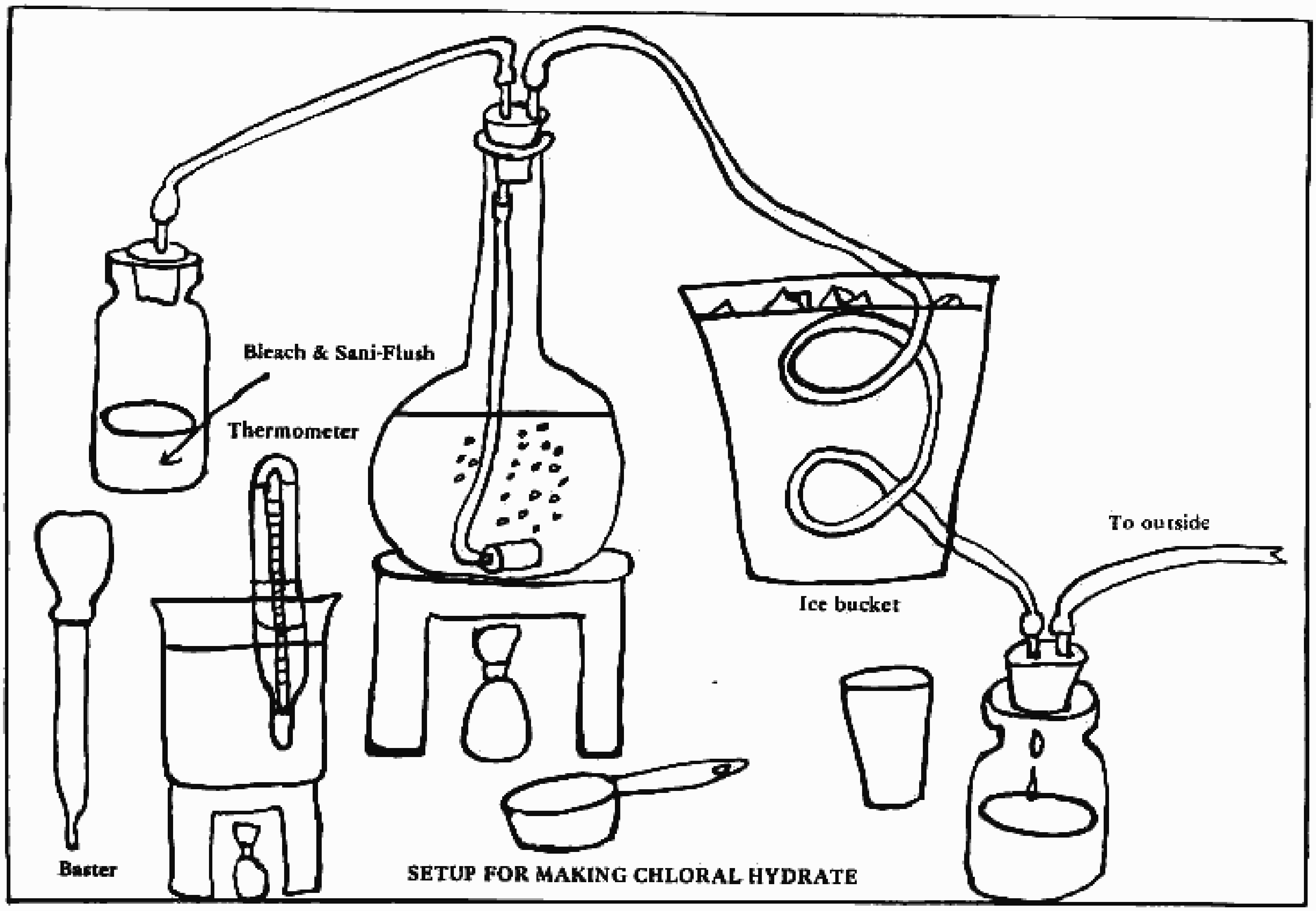
Start the chlorine through the alcohol while the flask is cold. Watch the flask carefully to see when the alcohol stops absorbing the chlorine. Then light the alcohol lamp with its wick turned down or with the stand on blocks so only a gentle heat will be made. When the alcohol stops absorbing again, raise the heat.

Keep this up until the alcohol is boiling. Finally it will no longer pick up any chlorine. Then, this part of the process is finished.

Some of the alcohol will have distilled off. It will go into the collecting bottle while the waste chlorine gas goes outside. Several times during the process, this alcohol is poured back into the flask.

When the alcohol is totally chlorinated the contents of the flask is poured into a porcelain pan and allowed to cool. If you have done it right the cooled product should be a crystaline mass of unrefined chloral hydrate.

Then, strong sulfuric acid, three times the volume of the chloral hydrate, is slowly poured into the pan. The pan is then put on the



SETUP FOR MAKING CHLORAL HYDRATE

stove over a gentle heat.

When the chloral hydrate is melted, it and the sulfuric acid are stirred thoroughly and part of the mixture is poured into the 600 ml beaker and put over the alcohol lamp. Don't let the mixture in the beaker get over 200 F as it will begin to boil away at 210 F. This is where the thermometer comes into play.

As the mixture heats up, the still impure chloral hydrate will rise to the surface in the beaker. When it stops rising, take the basting syringe and collect it off the top of the sulfuric acid. It doesn't matter if you pick up a little sulfuric acid as long as you get all the chloral hydrate. Store it in the water glass.

Repeat the last process until the pan is empty.

The still impure chloral hydrate is then put into the beaker. Then it is heated at about 190 degrees F for 20 minutes to drive off all the unchlorinated alcohol and hydrochloric acid.

The next step is to pour the chloral hydrate back into the flask and add an equal amount of sulfuric acid. The contents are then swirled around to mix.

The chloral hydrate is then distilled out of the sulfuric acid. This is easy to do as chloral hydrate boils at 210 F and sulfuric acid boils at 722 F.

When the distilling is over the sulfuric acid is poured out and the flask is washed and dried. Then finely powdered calcium oxide, equal in volume to the chloral hydrate, is put into the flask. The chloral hydrate is then added and distilled again. The process is stopped as soon as the chloral hydrate has nearly stopped dripping into the collecting jar and the surface of the calcium oxide is dry.

To prepare for use, add to the finished chloral hydrate, one part of water to two parts, by volume, of the finished product.

Chloral hydrate is a hypnotic and many people become addicted to it. Taking it yourself is a no-no.

This process has proven difficult for some. It does work, however. But if you have trouble with it, study Dick's process (4276-7) and the directions given in the 1892 edition of The Encyclopedia Britanica, below.

CHLORAL, TRICHLORALDEHYDE, or HYDRIDE OF TRICHLORACETYL, C_2Cl_3OH or $CCl_3.COH$, a substance discovered by Liebig in 1832, and further studied by Dumas and Städeler. It is a heavy, oily, and colourless liquid, of specific gravity 1·518 at 0° C., and boiling point 94°·4 C. It has a greasy, somewhat bitter taste, and gives off a vapour at ordinary temperature which has a pungent odour and an irritating effect on the eyes. The word *chloral* is derived from the first syllables of *chlorine* and *alcohol*, the names of the substances employed for its preparation. Chloral is soluble in alcohol and ether, in less than its own weight of water, and in four times its weight of chloroform; it absorbs but is not acted upon by chlorine, and dissolves bromine, iodine, phosphorus, and sulphur. Chloral deliquesces in the air, and, like aldehyde, is converted by water into a hydrate, with evolution of heat; it combines also with ethylic alcohol and its homologues, and the derived mercaptans. An ammoniacal solution of nitrate of silver is reduced by chloral; sulphites of the alkalies form with it crystalline compounds; and nascent hydrogen, by replacing its three atoms of chlorine, converts it into aldehyde (Personne, *Ann. Ch. Pharm.*, clvii. 113). By means of phosphorus pentachloride, chlorine can be substituted for the oxygen of chloral, the body $CCl_3.CCl_2H$ being produced; an analogous compound, $CCl_3.C(C_6H_5)_2H$, containing the radicle phenyl in the place of the oxygen, is obtained by treating chloral with benzene and sulphuric acid. With an alkali, chloral gives chloroform and a formate of the base according to the reaction $CCl_3.COH + KHO = CCl_3H + H.CO(OK)$; it is converted by oxidizing agents into trichloracetic acid $CCl_3.CO(OH)$; and forms with cyanic acid the body $C_5H_3Cl_6NO_3 = (CCl_3.COH)_2 \cdot COHN$. When kept for some days, as also when placed in contact with sulphuric acid or a very small quantity of water, chloral undergoes spontaneous change into the polymeride *metachloral*, $C_6H_3Cl_9O_3 = (C_2Cl_3OH)_3$, a white porcelaneous body, slowly volatile in the air, insoluble in water, alcohol, and ether, and reconverted into chloral without melting at 180° C.

Chloral is prepared by passing dry chlorine into absolute alcohol; the latter must be cooled at first, but towards the end of the operation has to be heated nearly to boiling. The alcohol becomes converted finally into a syrupy fluid, from which chloral is procured by treatment with sulphuric acid. The action of chlorine upon alcohol is complex;—first aldehyde, $CH_3.COH$, is produced, which combines with alcohol to form acetal, $CH_3.CH(OC_2H_5)_2$; this, acted on by chlorine, yields trichloracetal, $CCl_3.CH(OC_2H_5)_2$, which is converted by the hydrochloric acid present into chloral alcoholate, $CCl_3.CH.OH.OC_2H_5$, and monochlorethane, C_2H_5Cl. The latter body is also formed directly from alcohol, in the process for the manufacture of chloral, and combines with aldehyde, giving monochlorinated ethylic ether, $CH_3CHCl.OC_2H_5$, which is converted by chlorine into tetrachlorinated ether, $CCl_3.CHCl.OC_2H_5$. By the action of sulphuric acid, chloral alcoholate and tetrachlorinated ether are resolved into alcohol and chloral, and monochlorethane and chloral, respectively. The crude chloral is distilled over lime, and is purified by further treatment with sulphuric acid, and by redistillation.

A mixture of starch or sugar with manganese peroxide and hydrochloric acid may be employed instead of alcohol and chlorine for the manufacture of chloral (Städeler, *Ann. Ch. Pharm.*, lxi. 101–121). An isomer of chloral, *parachloralide*, is made by passing excess of dry chlorine into absolute methylic alcohol; it is a colourless liquid, insoluble in water, and boils at 182° C. (Cloëz, *Ann. Ch. Pharm.*, iii. 180).

Chloral hydrate, $C_2Cl_3OH.H_2O$, or $CCl_3.CH(OH)_2$, the compound formed by the union of water with chloral, occurs in the form of oblique, often very short, rhombic prisms; an acicular form of crystals is considered by Paul to be characteristic only of the alcoholate. The purest samples of chloral hydrate present the appearance of ordinary alum broken into fragments, are perfectly transparent, only slightly odorous, free from powder, and dry to the touch, and do not become white by exposure. Jacobsen gives the melting point of pure chloral hydrate as 50° to 51°, the boiling point as 99° C. It can be distilled unchanged at 120°C.; but when heated with sulphuric acid it is converted into anhydrous chloral and *chloralide*, $C_5H_2Cl_6O_3$. When mixed with water, chloral hydrate causes a considerable degree of cold; and, as with camphor, small fragments of it placed on the surface of water exhibit gyratory movements. An aqueous solution should be neutral or nearly so, and should give but a faint milkiness when boiled with silver nitrate. A drop or two of ammonia added to solutions assists in their preservation. Chloral hydrate may be detected in the presence of other substances by adding an alkali and heating, when chloroform is evolved, which may be collected in a receiver; this process can be employed for the estimation of the commercial hydrate. When ammonium sulphide is added to a solution of pure chloral hydrate, the liquid turns red, and then becomes rapidly brown and thick; the presence of oily impurities in a solution is shown by the brown colour it acquires when shaken up with concentrated sulphuric acid. Chloral hydrate has the property of checking the decomposition of a great number of albuminous substances, such as milk and meat; and a mixture of it with glycerine, according to Personne, is suitable for the preservation of anatomical preparations. When heated with concentrated glycerine to a temperature of 110°–230° C., chloral hydrate yields chloroform, $CHCl_3$, and formate of allyl, $HCO(OC_3H_5)$; and by the action of nitric acid and strong sunlight, at 195° C. it is transformed into trichloracetic acid, $CCl_3.COOH$. The effect of chloral hydrate upon fresh blood, like that of formic acid, is to render it darker.

The breaking up of chloral hydrate, in the presence of alkalies, with the production of chloroform and formates, led Liebreich to the conjecture that a similar decomposition might be produced in the blood; and hence his introduction of the drug, in 1869, as an anæsthetic and hypnotic (*Compt. rend.*, 1869, lxix., 486). It has been supposed that its physiological action may be due to formic acid as well as to chloroform set free in the blood, the effects of the formic acid being attributed to the production from it of carbon dioxide. Personne, however, has administered sodium formate to dogs, without perceiving in them the slightest anæsthetic phenomena, or the abnormal formation of carbon dioxide (*Compt. rend.*, 1874, lxxviii. 129). He considers that chloroform is set free in the blood, but is not eliminated as such, being converted into sodium chloride and formate (*ibid.* 1869, lxix., 983); the prolonged action of chloral on the animal economy he explains on the supposition that, chloroform being produced at the expense of the alkali of the albumen of the blood, the latter, which may be regarded as an amide, forms with the trichlorinated aldehyde chloral a compound which, by the gradual action of the blood, affords a continuous supply of chloroform. Tanret, on the other hand, suggests that as chloral hydrate, when made alkaline with caustic potash, yields in the presence of the oxidizing agent potassium permanganate the formate, chloride, and carbonate of potassium, together with carbon monoxide, the alkalinity of the serum of the blood may determine a similar decomposition of chloral hydrate, the physiological effects of which may therefore be ascribed to poisoning or deoxidation of arterial blood by carbon monoxide (*Compt. rend.*, lxxix. 662; *Journ. Pharm. Chim.* (4), xx. 355–357).

The first effect of a dose of chloral hydrate is to produce a state of congestion of the brain, as evidenced by the condition of the retinal vessels; after 5 or 10 minutes, contraction of the vessels is observed, the retina becomes of a pale pink colour, and drowsiness ensues; when this wears off, the retinal and cerebral vessels resume their accustomed size (Dr W. A. Hammond). In cases of death from chloral, the cerebral vessels have been found much congested.

The effects of chloral hydrate vary with different individuals; but, as a rule, a dose of 20 grains acts in a healthy subject as a mild sedative of the sensory nervous system, and produces, about half or three quarters of an hour after it has been taken, a light, refreshing, and normal sleep, without causing headache or disturbance of the respiration and pulse.

Taken in large quantities chloral hydrate is a powerful soporific; it perceptibly lowers the temperature of the body, and diminishes the frequency and force of the heart's action, probably from paralysis of its intrinsic motor-ganglia; whilst the rate of respiration is lessened, apparently through affection of the medulla oblongata. Excessive doses produce complete insensibility, and diminish, and at last abolish reflex excitability; pallor, coldness of the extremities, lividity, and muscular relaxation ensue; and death may result from cardiac syncope.

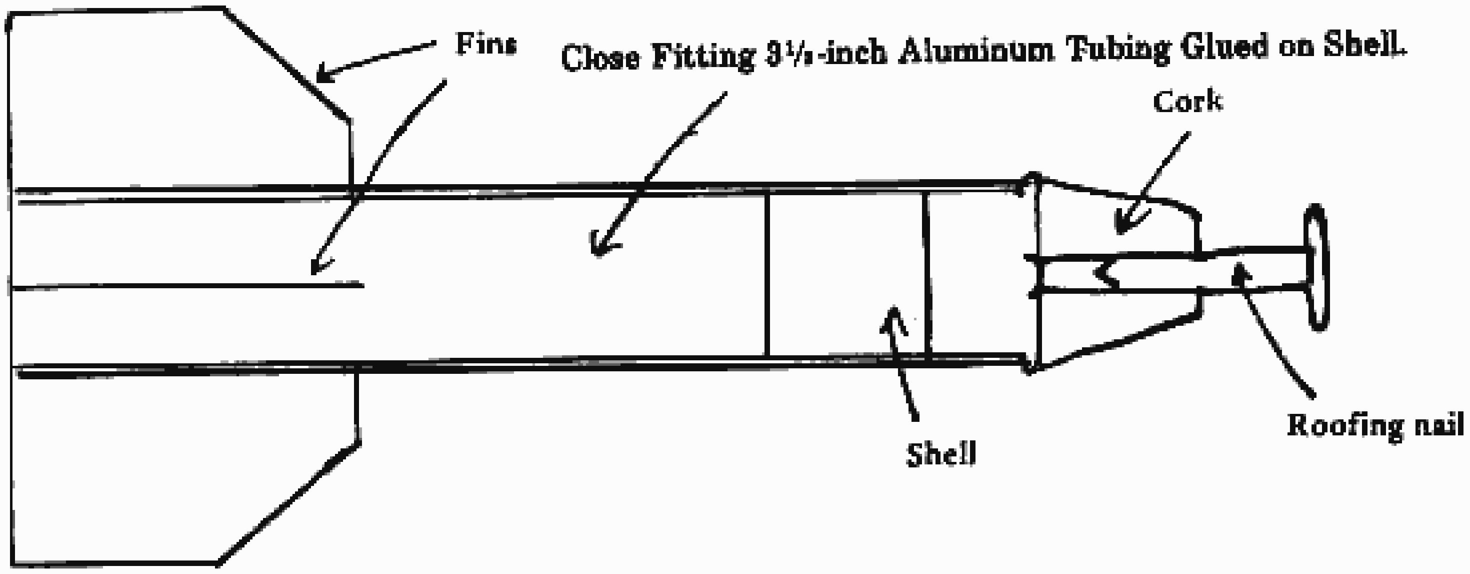
M Oré is the originator of a plan for performing operations during anæsthesia produced by the intra-venous injection of chloral hydrate. He shows (*Compt. rend.*, 1874, lxxviii. 515, 651) that it may be harmlessly injected, and that when thus brought into immediate contact with the blood, it effects complete anæsthesia of long duration, and is a rapid and effectual remedy for tetanus. Chloral hydrate sometimes fails to afford relief from suffering, and when it does not induce sleep, may occasion excitement and delirium. In some cases a dose has produced an eruption of urticaria. It must be administered with caution to children, and to patients having disease of the heart and of the digestive tract, certain affections of the bronchi, or hysteria. It appears that chloral cannot be decomposed and thrown off by a healthy body at a greater rate than from 5 to 7 grains an hour (Richardson, *Lancet*, 1871, 1, 209); and as the limit of the dose that can be safely taken is not affected by the customary use of the drug, as in the case of opium, but rather the reverse, its incautious employment in large quantities, and the practise of habitually resorting to it to gain relief from sleeplessness, from neuralgia, and from the effects of alcoholic excess, have in not a few instances led to fatal results. In consequence of this risk medical practitioners now use it less extensively. The continued use of chloral hydrate, too, is apt to cause a hyperæmic condition of the skin, diffuse inflammatory erythema of the face and chest, conjunctivitis, and interference with respiration; and may bring on deep melancholy, weakness of will, and inability to sleep without the drug.

Chloral hydrate is of special value as a soporific where opium is inadmissible, as in the case of children, in uræmia, and in some fevers. It is used in delirium tremens, rabies, severe chorea, acute mania, and phthisis, as well as in dyspnœa, pertussis, cholera, sea-sickness, cancer, chronic rheumatism, and gastralgia, and in parturition and eclampsia; and in cases of tetanus it is employed to produce muscular relaxation. Its antagonism to strychnia was first pointed out by Liebreich (*Compt. rend.*, 1870, lxx. 403). When administered to rabbits it has been found to be a remedy for poisonous doses of strychnia (Bennett, *Edin. Med. Journ.*, 1870, xvi. 262); but Oré has shown (*Gaz. Médic. de Paris*, 1872, p. 401) that the hypodermic injection of that drug is of no avail in the case of rabbits poisoned with fatal doses of chloral hydrate. Numerous experiments have led to the conclusions that "chloral hydrate is more likely to save life after a fatal dose of strychnia, than strychnia is to save life after a fatal dose of chloral hydrate;" that after a dose of strychnine has produced tetanic convulsions, these convulsions may be reduced in force and frequency, and life may be saved, by means of the influence of chloral hydrate; but that though the effects of a poisonous dose of the hydrate may be mitigated, the coma produced by its action on the brain is not removed by strychnia (Bennett, Report in *Brit. Med. Jour.*, 1875, 1, 97; Ogilvie Will, *Edin. Med. Jour.*, April 1875, 907). Chloral hydrate modifies the action of a fatal dose of extract of Calabar bean, but is of little service if given some time after the latter. The effects of chloralism are combated by provoking emesis, and by stimulating freely.

FIRE BOMBS

Most fire bombs are simply gasoline filled bottles with a fuel soaked rag in the mouth (the bottle's mouth, not yours). The original Molotov cocktail, and still about the best, was a mixture of one part gasoline and one part motor oil. The oil helps it to cling to what it splatters on.

Some use one part roofing tar and one part gasoline. Fire bombs have been found which were made by pouring melted wax into gasoline.



SHOTGUN SHELL BOMB

SHOTGUN SHELL BOMBS

These little goodies are affectionately known as "nut busters." They are simply shotgun shells enclosed in cardboard rolls with cardboard fins put on. On the primer end of the shell is glued a small cork with a hole drilled through it. A roofing nail fits in the hole snugly enough to stay in but loose enough to plunge into the primer upon impact.

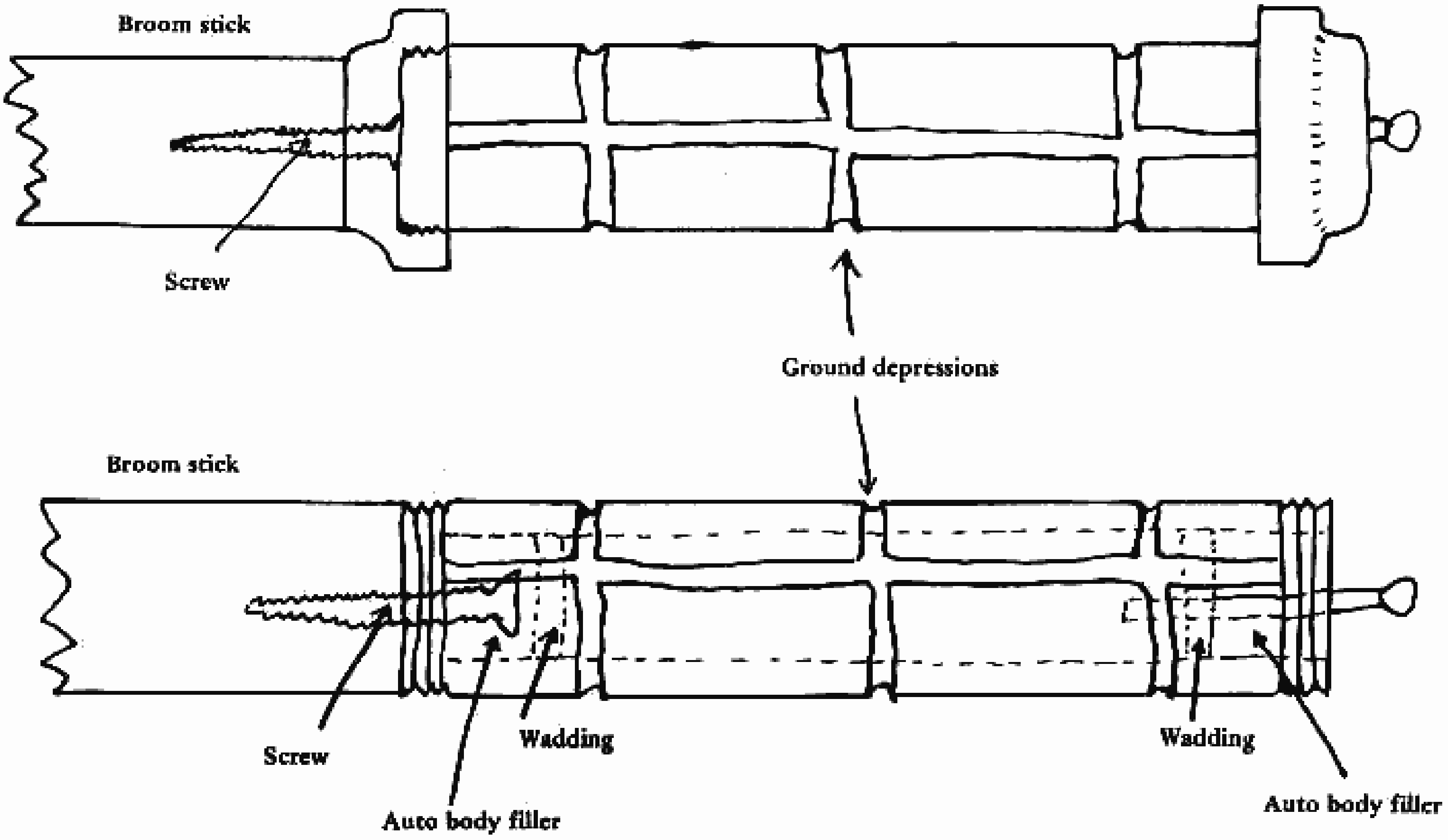
Since the shell is not confined in the chamber of a gun, it will naturally not cause the same amount of damage. But if it goes off between a fellow's legs he can look forward to becoming a soprano.

These bombs are thrown singly or by the handfull into the air over milling crowds. The weight of the shell and the stabilization by the fins causes the nut buster to head straight downward.

It has tremendous effect as its presence is usually a surprise. The threat of more coming in is guaranteed to rout any mob.

Not only does it go off on the pavement but it will also explode on contact with a person's head or shoulder. At night it is impossible to trace its point of origin.

A clever use for a plain shotgun shell is as a muffler bomb. The shell is simply shoved up a car's exhaust pipe with a length of stiff wire until it drops into the muffler. After a few minutes on the road the shell explodes, totalling out the muffler and treating the driver to a sick kind of panic.



POTATO MASHER GRENADES

POTATO MASHER GRENADES

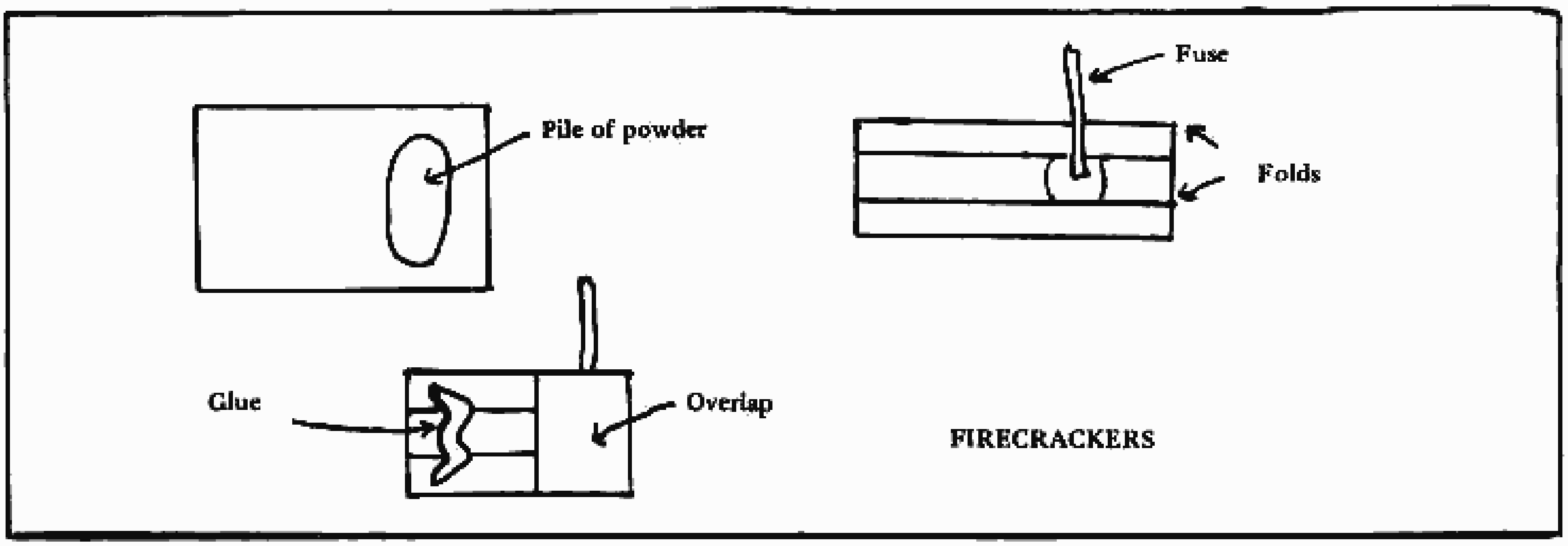
A grenade on the end of an eight-inch piece of broom stick can be thrown almost twice as far as when you hold the grenade directly in your hand.

As illustrated, both caps are drilled and the bottom cap is fitted with a screw that goes into the stick. The piece of broom stick is also drilled but a size smaller than the screw. This is to make the screw go in easier without splitting the stick.

The fuse is cut the length it takes about five seconds to burn. It is glued firmly into the cap and generously covered with flare igniter. To ignite, the fuse is scratched with a strip of wood covered with red phosphorus and sand.

Pipe grenades can be caused to fragment simply by grinding depressions in them with a grinding wheel. The depressions are made before the explosive is put in. Depressions 1/16 inch deep cut the resistance of the pipe enough to make it shatter.

If you have any skill at all you can grind such a grenade in about two minutes.



FIRECRACKERS

FIRECRACKERS

Firecrackers are so simple to make that many books on fireworks ignore them. There are two main types of firecrackers but many mixtures.

Handmade giant firecrackers are made by first rolling paper around a 3/4 inch dowel until the paper is 1/8 inch thick. This is the case.

The best paper to use is from paper sacks. It is cut to the desired width and the length that makes it 1/8 inch thick when rolled. On the last roll, the paper is glued and the tube is slipped off the dowel.

One-quarter inch thick slices of the dowel are used to plug the ends.

The plug for the fuse end is drilled to allow for the fuse. The plugs are smeared with glue before being pressed into the ends of the tube. More glue is squeezed in around the fuse after it is put in.

In all the directions I have for making giant firecrackers it is recommended that they be filled only one-third. It is agreed by all who wrote about them that completely full ones aren't as loud as those that are one-third full.

I admit to never having made one. I did play with them as a child and used them more for their destructive properties than for their noise. They do have terrific force, even when only one-third full.

Anyone wanting to make them can test for himself whether there is more concussive force in a full firecracker or one which is only one-third full.

If you choose the one-third full kind you should be sure to put the fuse well into the firecracker to make sure it reaches the powder.

For the small firecracker, two kinds of paper are used. Any regular paper is used for the tube but thin wrapping tissue is used for the inside.

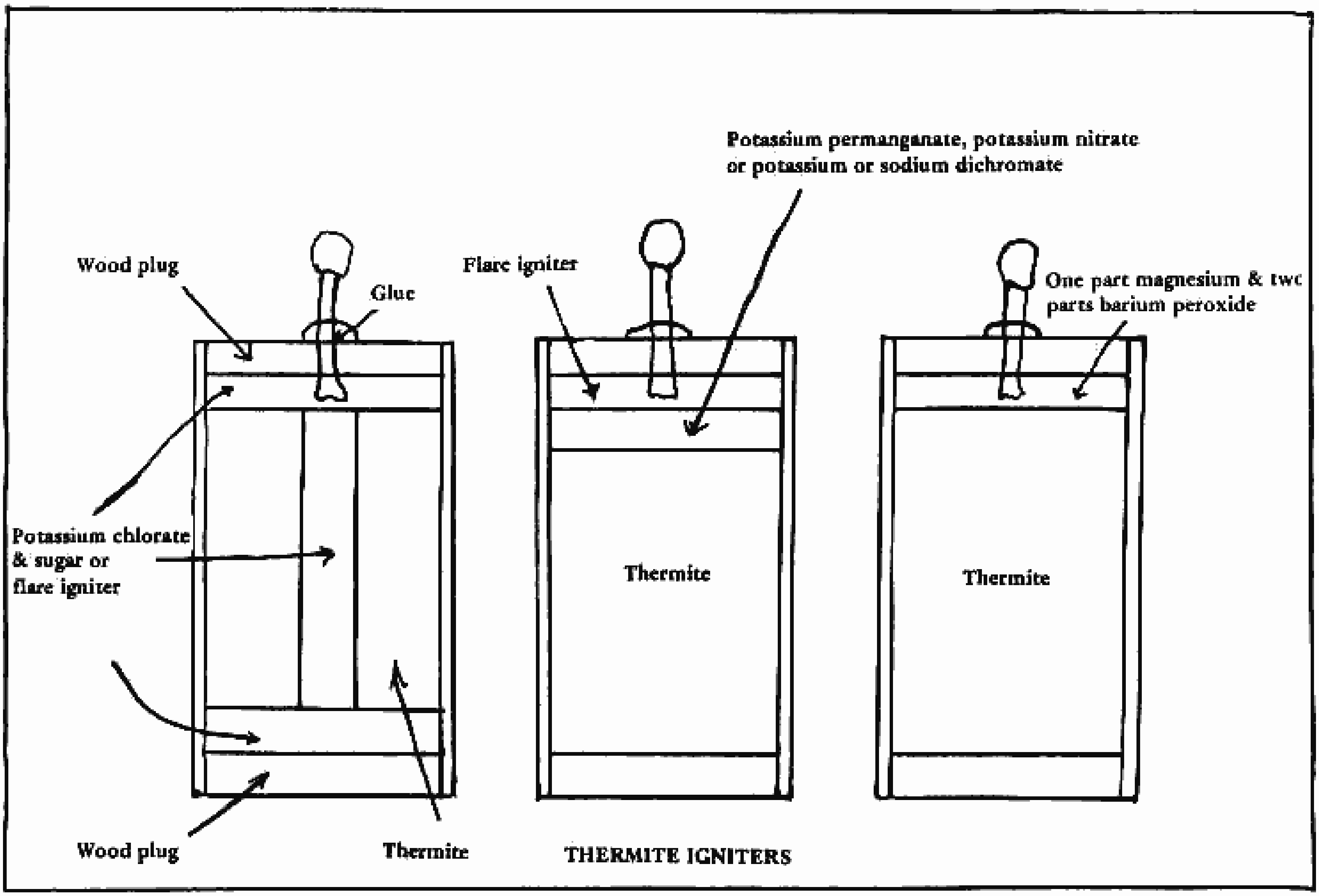
As illustrated, a pile of powder is put on the tissue. The edges are folded over and the fuse is placed so its end is in the powder area.

The short end of the tissue is then lapped over the powder and fuse. Next, the whole thing is rolled tightly to the end over the glue.

The outside is a strip of paper about 11 inches long and slightly wider than the length of the powder core. It is smeared lightly with glue and rolled tightly around the powder core.

If any glue is water based, the firecrackers are allowed to dry for a couple of days. Then airplane glue is squeezed into both ends.

Adequate firecrackers can be made with commercial gunpowders. Pistol powder is best but even shotgun powder will do.


Potassium permanganate, potassium nitrate
or potassium or sodium dichromate
Wood plug
Glue
Flare igniter
One part magnesium & two
parts barium peroxide
Potassium chlorate
& sugar or
flare igniter
Thermite
Thermite
Wood plug
Thermite

THERMITE IGNITERS

Of the many powder formulas to choose from, I picked three as being the most practical and stable.

The first is four parts potassium nitrate, one part sulfur. The second is, six parts potassium nitrate, two parts aluminum powder and three parts sulfur. The third is five parts barium nitrate, two parts aluminum powder and one part sulfur.

The potassium nitrate and charcoal are both ground as finely as possible before being mixed. An electric blender can be used to pulverize both but should never be used for any other explosive stuff.

INCENDIARIES

For sheer terrorism, incendiaries can't be beat. They are horrifying to look at and if set off in a crowded room, instant panic is guaranteed. They burn at 4,000 degrees and give out a blinding light.

Wartime incendiaries had magnesium casings which burned fiercely. If water was put on them they disintegrated, sending burning metal in all directions. You probably can't get hold of magnesium tubing so you will have to settle for aluminum.

Aluminum tubing, bought at any hardware store, is the next best casing for improvised incendiaries. It doesn't burn as fiercely as magnesium but is still pretty awful.

The tubing should be at least 1½ inches in diameter. This is to make sure there is enough thermite to burn the tubing.

Aluminum tubing is cut into suitable

lengths and slices of a large dowel are cut for plugs. One slice is drilled to accommodate the fuse.

Thermite is a mixture of three parts, by volume, of red or black iron oxide and two parts of fine aluminum powder.

The tube is filled nearly full and tamped until the thermite is one inch from the top. A circle of tissue paper is then put in to keep the thermite from blending with the igniter.

The igniter is a mixture of one part, by weight, of powdered magnesium and two parts of barium peroxide. This is mixed carefully, preferably by rolling back and forth in a plastic container. It isn't all that sensitive but it doesn't hurt to be cautious. Goggles and gloves should always be worn when working with explosive or flammable substances.

When mixed, a one-half inch layer of thermite igniter is put into the tube. Another circle of tissue is added and one-fourth of an inch of flare igniter is spread in. The one-fourth inch of inside tubing is cleaned of flare igniter to accommodate the plug.

A bare fuse is stuck straight up in the center of the flare igniter and it is left to dry for a day or two. Then the drilled plug is smeared with glue and pushed over the fuse. Then flare igniter is daubed on the fuse and when dry, the thing is ready to use.

OTHER THERMITE IGNITERS

Thermite can also be ignited by potassium chlorate and sugar or flare igniter, although not as reliably as with the barium peroxide and magnesium.

To make a thermite grenade which will ignite by potassium chlorate and sugar or flare igniter, you start with aluminum tubing 1½ inches in diameter, or more, and five inches long.

Buy a length of dowel that fits snugly inside the tube. Cut one-fourth inch thick slices of the dowel to plug both ends. Bore fuse

holes in the slices that are to be used for the tops of the grenades.

Put glue around the bottom slices and put them in the ends of the tubes. When the glue is dry, put in a one-fourth inch layer of three parts, by volume, of potassium chlorate and two parts of sugar, well mixed, or flare igniter. Then put in a circle of tissue over the mixture so it stays by itself.

Next, wrap a pencil once with a 4¼ inch piece of tissue and hold it in the center of the tube while you pour in the thermite. When the tube is full, tamp the thermite down, being careful not to damage the tissue around the pencil. Put in and tamp the thermite until it fills the tube to one-half inch from the top.

The pencil is then carefully removed from the tissue tube and potassium chlorate and sugar or flare igniter is funneled in until it meets the top of the thermite.

Then, put in another circle of tissue over the thermite and add a one-fourth inch layer of potassium chlorate and sugar or flare igniter. Next put in the plug and the fuse. Glue is squeezed in around the fuse to hold it in place.

OTHER IGNITERS

Potassium permanganate, potassium nitrate and potassium or sodium dichromate can all be used to ignite thermite. However, they won't ignite by fuse so must be helped along by an additional igniter.

First, either of these igniters must be crushed to the fineness of granulated sugar. A quarter-inch of the igniter is poured over the thermite and a quarter-inch of flare igniter is spread over it.

The fuse is stuck straight up in the flare igniter and the mess is allowed to dry for a couple of days. Then the plug is glued and put over the fuse and pressed firmly into the end of the tube. It is good to squeeze some more glue around the fuse as the flare igniter doesn't hold it very well.

DYNAMITE

Many Militants use dynamite. In some states it takes a fire marshal's permit to buy dynamite but such a permit is easy to get. All you have to do is file a mining claim in some desert wasteland. The land office, usually in the courthouse, is where to learn how to go about filing a claim. Then you take your claim to the fire marshal and if you are not an obvious freak he will give you a permit.

The mineral you claim to be hunting will depend on your own area. In the courthouse there is usually a geological survey office where they can give you a list of minerals mined in your area.

You should choose one that requires blasting.

One Militant was out in the boondocks and found several outcroppings of pretty rocks. He figured they would look great in aquariums. He filed his claim and got his permit.

After doing enough blasting to prove he was using his dynamite legitimately, he was supposed to share all the rest he bought with his friends. But he uses it all for blasting and is fast becoming the aquarium rock king of Southern California. Now he looks down on his former friends.

Not all Militants are like him. They file their Mickey Mouse claim and after a little blasting to make the area look like it is being worked they buy all the rest to sell to friends.

With your permit you can buy dynamite for $20.00 for 100 sticks and resell it for $2.00 per stick. Less the small cost for blasting caps and a little fuse given with each sale, you will make 1,000% profit. If you steal it your margin of profit will be even greater.

Dynamite is bought from stores selling to miners. Such stores can be located through the business section of the phone book under "Explosives."

Militants in the service, and especially the National Guard, steal great quantities of explosives as well as military equipment and supply their civilian friends. Dynamite is also stolen from construction sites, even in the middle of large cities.

Dynamite ranges in explosive velocity from 4,000 to 23,000 feet per second. The lower velocities are used for moving earth and such and the higher velocities are used for their shattering effect on stone and steel.

Lower velocity dynamites are made up from 20 to 60% nitroglycerine with sand, clay or sawdust as an absorbent.

The low velocity dynamites are very dangerous to store because the nitro settles to the bottom in a few months and the stuff has to be turned every couple of weeks, like hatching eggs. If not turned, the settled nitro can explode at the slightest jar.

If you are smart you will buy only the gelatin dynamites. They are made up of up to 90% nitro and the rest is nitrocotton. These are the most powerful. These are also safer to store, as they become less sensitive with age and don't have to be turned.

THE STILL

Once the Militant has his chemicals, he sets up his still. It is small, efficient and safe. In it he makes things like tear gas, prussic acid and occasionaly distills alcohol.

First, a flask is fitted with a one-hole rubber stopper. A short length of thin glass tubing is inserted into the hole. A five foot length of thin rubber tubing is fitted over the glass tube and coiled into the ice bucket and out through a hole near the bottom. The end of the tube is fitted over another glass tube which is in a two-hole stopper stuck into a bottle. The other hole contains another glass tube to which is attached another length of tubing long enough to reach outside to get rid of any noxious or poisonous fumes.

The equipment for the still is cheap and simple to get. Most of it can be bought from your local drug store. They carry tubing, stoppers, glassware and many chemicals which they freely sell to doctors, students, etc. If you get on good terms with your druggist and he doesn't know you're a freak you can buy most of your stuff from him.

A ring stand or tripod for the flask is more handy than the can in the illustration. But a tin can with strips cut out of it for ventilation and for the removal of the lamp is usually adequate.

The checklist of equipment is:

1. alcohol lamp. 2. ring stand, tripod or tin can. 3. 500 ml or larger flask. 4. assortment of one and two-hole and holeless rubber stoppers of various sizes. 5. about six yards of 3/16 of an inch (inside diameter) rubber tubing. 6. about a foot of six millimeter (outside diameter) laboratory glass tubing. 7. child's plastic bucket. 8. receiving bottle.

The hole in the bucket for the tube is made somewhat smaller than the tube so it will fit snugly and prevent leakage.

Full strength wood alcohol for the lamp can be bought at the drug store. Rubbing alcohol, although 30% water will burn in the lamp but not so well. You can distill the pure alcohol off the water from rubbing alcohol.

This is best done over a gas or electric stove. First a large pan with a couple of inches of water in it is put on the burner to be used and the others are turned off.

The still is set up as in the illustration except the receiving bottle is larger and doesn't need a stopper or tube going outside. The flask is filled with rubbing alcohol to just under the neck and set in the pan of boiling water.

In this setup a coathanger wire with a loop in its middle is put over the neck of the flask and fixed to the sides of the pan. This is necessary because as the alcohol distills off, the flask gets lighter and would rise in the water and fall over without support.

Another consideration is to make sure the tube does not flop over and collapse. This can be prevented by hanging a string from the ceiling by which the tubing is held above the flask.

The tubing should be further supported so it does not touch the hot edge of the pan. If it is allowed to lie over the edge it will melt.

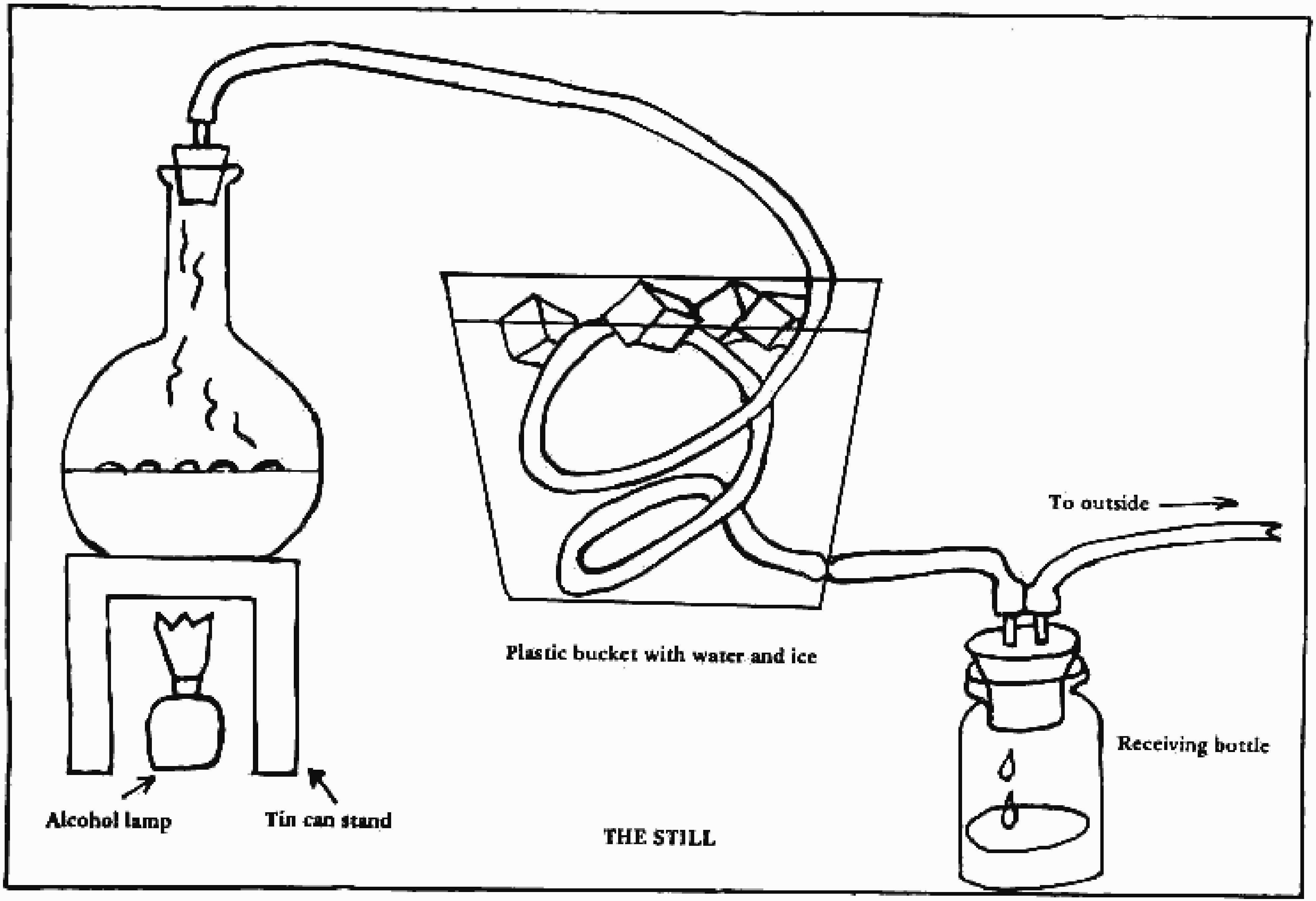
When the action starts the alcohol will fairly flow into the collecting bottle. When it stops all that is left in the flask will be water. If left alone, water would start dripping, much slower than the alcohol, but this is not wanted.

This is the only case where you should distill over a stove. A stove is harder to control than an alcohol lamp. It is also harder to clean up than a table in case of an accident.

TEAR GAS

There are several eye and nose irritants on the market which can be easily duplicated by Militants. One is "Defend." It is advertized as leaving a red stain so an attacker can be identified. The stain is not visible and the active ingredient is common household ammonia. Forget it. Besides, ammonia turns to water in a few seconds and is more likely to enrage than to repel an attacker.

A much better irritant is formaldehyde. Better known as embalming fluid, it smells horrible, hurts the eyes and nose, and on exposure to the air it vaporizes, making a room



THE STILL

uninhabitable for hours.

It can be squirted from a water pistol or nasal inhaler, poured on the floor or vaporized by a bomb described under stinkum.

This was accidentally tested after a visit to the Avilas of Eureka, California. I threw my jacket on an easy chair and my anahist nasal sprayer fell out. It was filled with formaldehyde which I carry for vicious dogs and members of the Eureka City Council.

Mrs. Avila found it later and put it on the kitchen table. Her sixteen year old daughter, Laura, saw it and, feeling an attack of the sniffles, did then take it and squirt it up her left nostril.

The action got pretty heavy about then as she went into convulsions and almost blacked out. She wiped her hand across her nose and got some formaldehyde under her upper lip. This was so painful she thought she would lose her mouth.

A scratch on the back of her hand got some formaldehyde and the agony was almost as bad as everything else. Even though none had gotten directly into her eyes, they began to tear copiously and she could hardly see.

She was totally incapacitated for at least twenty-five minutes. She couldn't do a thing except yell. She regained her sense of smell several hours later and luckily there was no lasting damage.

Formaldehyde can be bought at the drug store under the pretext of wanting it to preserve mice or other lab specimens.

The irritant mailmen use against dogs and which is sold widely for self defense is oleoresin capsicum. Capsicum is the hot essence of red peppers. Oleoresin is the process for extracting it.

To extract the capsicum, grind up four ounces of red pepper seeds in a blender or with a mortar and pestle. Red pepper seeds are bought in the grocer's.

The dry, ground seeds are then put into a coffee percolator in which there is about 16 ounces of alcohol, preferably with the water distilled out. The seeds are then percolated for about a half hour.

The alcohol is then distilled off until there are only a couple of tablespoons of red liquid left in the flask. The red liquid is then added to a half pint of light mineral oil, bought at a drug store.

It can be sprayed from a nasal spray. Another good way is with a window cleaning sprayer bought at any dime store. The tube of the sprayer is cut to fit in a two ounce medicine bottle. This way you have enough goody to last through a whole demonstration, no matter which side you're on. It is also nice to keep by the door to repel intruders.

Before using, the container should be given a few shakes. Under laboratory conditions all the oil is extracted from the seeds. But with my Mickey Mouse method a lot of oil is left in so the residue is quite potent. Just be sure you strain out any larger bits so the sprayer hole is not clogged.

The ground seeds left in the percolator are dried and saved. They are great for throwing into the faces of people in a mob. If you really want a laugh, throw some broadcast from a theater balcony during the death scene in "Love Story."

The goody called MACE is probably only acrolein. If not, it works just as well as MACE and is simple and fun to produce.

Acrolein is not toxic but causes horrible pain in the nose and copious tears, and irritates the skin. A shot in the face from a water pistol or some other sprayer will put anyone out of the game for at least a half hour.

Acrolein is best made an ounce at a time. Put in the flask 2½ ounces of glycerine and 3/4 ounce of sodium bisulfate (Sani-Flush), both of which can be bought at any grocery store.

The still is set up like in the illustration with the outside tube connected as the fumes are bad.

When the mixture starts to bubble it must be watched constantly to make sure it does not bubble up into the neck of the flask. If it starts for the neck of the flask, remove the lamp until it settles down. If the lamp is too hot, the tin can is raised on small blocks until the right heat is gotten.

Distill off an ounce of acrolein and take away the lamp. An ounce is all this size batch is good for. Let the flask cool for an hour before opening and cleaning. Pour the residue down the sink and put your face over the drain to get a sample of the vapor. Jesus!

Then cap the receiving bottle and wash everything the acrolein was in contact with.

The best squirter for the three irritants above is a water pistol. Most water pistols leak badly so they must be transported barrel up so the goody won't ooze out around the trigger. It will leak when you use it so it is best to put it in a plastic sandwich bag with the opening held around the barrel with a rubberband. If the pistol has a trigger guard it should be cut off and then it can be used just as easily in a plastic bag as otherwise.

For casual carrying around, you can't beat a nasal spray. The best ones can be screwed open so the goody can be poured in. If not, you have to squeeze it and put its nozzle into the goody. When the pressure is released the irritant will be sucked up.

Such irritants are illegal to carry in some states. That's one of the reasons the nasal spray is best. If you are searched and it is found, there is little chance it will be recognized for what it is.

I don't know what advice to give you if the cop has the sniffles and goes to use some of your goody.

STINKUM

Iron sulfide is sold for $.35 for only 1/8th of an ounce. Easier to make, just as potent and costing about $.50 a quart is ammonium sulfide. It stinks to high heaven like rotten eggs and no one can stand to stay around it once it has been spilled on the floor or vaporized by an explosion.

To make some, you mix four ounces of sulfur with eight ounces of hydrated lime in a stew pot. A quart of water is added and the mess is heated and stirred until the sulfur has completely blended. The hydrated lime will sink to the bottom of the pan and the yellow liquid is then poured off into a bucket.

Take the bucket outside, if you have any sense, and add one pound of sulfate of ammonia. Stir it a minute and hold your nose. Then cover the bucket with plastic wrap and let it set for about a half hour. Then pour off the liquid slowly through a cloth filter into a bottle.

If you don't have an outside you can use your bathroom. Just hope no one has to go for an hour or so. The liquid is vile but it is not poison.

Incidentally, when I researched this formula I went to the garden store and bought a five pound bag of sulfate of ammonia for $1.65. Garden sulfur is very high grade and makes excellent gunpowder. It has 10% inert ingredients so 10% more should be added to any formula requiring sulfur. I bought the hydrated lime from a building supply store for $.10 a pound.

A word is in order about the spelling used for sulfur products. Different spellings are: sulfur, sulphur, sulfate, sulphate, sulfide, sulphide, etc.

Stinkum is either poured on the floor, shot from a water pistol, thrown in a bottle or light bulb or vaporized by a firecracker. The same goes for the formaldehyde or acrolein.

THE HYDROCHLORIC ACID GOODY

The hydrocloric acid goody is the most fun in the whole book. It takes many forms and works on the principle that hydrochloric acid reacts with aluminum powder, foil or metal, releasing a great, dark cloud of noxious gas which looks horrible and smells worse.

Hydrochloric acid is used for killing algae in swimming pools and for cleaning tile and stone work.

Where swimming pools are common it can be bought at the supermarket for less than a dollar a gallon. It is also sold at hardware stores.

Being only 37% strength, it is seldom harmful to the skin but will eat through clothing like battery acid.

Hydrochloric acid is also known as muriatic acid.

On damp nights, a bottle of the acid alone, broken in the midst of a crowd, will form noxious clouds of chlorine gas. Scream "Poison gas!" and you will have a panic that will give you laughs for years.

When you get some, open it up and give it a sniff. It won't hurt you because you couldn't stand to smell enough to be harmed. Then put a couple of square inches of aluminum foil in a can in your sink and pour some acid on the foil. If the acid bottle has been tightly capped the reaction of breaking down the aluminum and producing a dark noxious gas should start in about a minute. If the bottle has been setting for months, poorly capped, the reaction may be immediate. You can stop the action at any time by turning on the faucet and flooding the aluminum with water.

When you have tested the reaction with foil, try it with powder and then with aluminum metal cut from a pipe or a slab.

The versatility of the hydrochloric acid goody is amazing and should keep you fascinated for hours.

Of course, the Militant's most common use of the hydrochloric acid goody is to clear areas of people he doesn't like. In a movie or a meeting hall a tin can half full of aluminum powder, foil or chunks is put under a seat. The acid is in a bottle with its mouth covered with a couple of plastic bags held in place with a rubber band. You can also use a plain rubber or a balloon over the mouth of the bottle.

The cover is pierced with a pencil and the bottle is upended into the can, after which, the Militant gets up and walks out. If the acid is old and reacts immediately, a wad of sponge is put over the aluminum, causing the needed delay.

A person sitting beside the Militant would not notice anything, especially if something exciting was happening up front. By the time he noticed the odor the reaction would have left him with nothing to do but run squealing and pissing from the scene.

The outside goody is great, too. It is used to break up parades and demonstrations and in riots, where it's every man for himself and the devil take the hindmost.

It is simply a pint or quart bottle (a quart is better) filled with goody and wrapped with several layers of aluminum foil and put in a paper sack.

Now, say a group of Militants infiltrate a civilian parade at different points. At an agreed upon time they yell, "They're throwing things!" Then, while the other paraders are looking around and up, the Militants crash their outside goodies, still in the sacks, to the pavement.

As the parade moves on, the Militants filter back to where the goodies are. When the reaction starts they scream, "Poison gas! Poison gas!" and panic the whole mob out of the action.

The aluminum wrapped bottles have to be slammed down hard or they might not break.

IGNITERS

Igniters range from powder fuses that smoke and burn and ignite the device in a few seconds, to chemical igniters that take minutes, to watch timers that ignite the device electrically hours later.

The simplest fuse is made from gunpowder mixture, using the dextrine or glue but omitting the graphite. A length of cotton twine is stirred in the mush, which is wetter than that to be used for gunpowder, and when well coated it is hung up to dry.

If a thicker fuse is wanted, the coated string is folded along its length once or twice, depending on how thick you want it. Then a heavy object is attached to one end and spun, twisting the strands. The other end of the fuse and the heavy object are secured so the strands will remain twisted until dry.

The dried fuse, whether one or more strands, is stiff and brittle. With any bending the powder drops off in spots, making it burn unevenly. If your fuse is going to be handled or will be out in damp weather, you should make some Micky Mouse safety fuse.

Up to three feet of masking tape is unrolled and placed sticky side up on a table. Three-quarter inch wide tape is used for one-strand fuse and one-and-one-quarter inch wide tape is used for the four-strand fuse.

The dry fuse is simply laid along the tape's edge and the tape is rolled over it until it is nice and tight. It is then cut into the desired lengths.

A more sophisticated safety fuse is made by coating the fuse with spray-on plastic from an aerosol can. When this dries the fuse is coated with rubber mold compound, bought at any hobby store. The plastic is used first because the mold compound has a water base and would wet the fuse. The rubber would dry but the fuse would stay damp indefinitely.

Fuses of all kinds are best lit with the material used to ignite highway flares. This is because matches often go out or the Militant's hands are shaking so badly he drops the match into his fly.

Commercial safety fuse is almost impossible to light with a match. Coating its end with flare igniter makes it easy to light and also keeps loose powder from dropping out the ends. This also applies to homemade or other fuses.

Flare igniter is gotten from highway flares you can buy from any auto supply or surplus store for as little as $.15 each. The black igniting core is dug out, crumbled and dissolved with carbon tetrachloride, bought at any auto supply store.

Carbon tetrachloride is commonly used for dissolving grease from auto parts. Just enough is used to dissolve the igniter and it is then evaporated off in a well ventilated area as the fumes are harmful.

The gray powder is then mixed with just enough water to make a thick paste. The fuse ends are then dipped into the paste and dried.

The most difficult to light fuses are easily lit by a match or even with a drop of sulfuric acid.

If you don't want to waste a lot of fun flares you can make your own ignition mixture, which is the same stuff as found in flares.

A lifetime supply of the black part is made with 1½ ounces of black antimony sulfide, 2½ ounces of potassium chlorate and one ounce of dextrine or 1½ ounces of Lepage's Mucilage.

The black antimony sulfide and the potassium chlorate are both wet before being mixed. If they are mixed dry an explosion can result. Then add dextrine or glue and enough water to make a thick paste.

You don't need much of the red striker mixture. One striker can be used to light many fuses.

The red striker mixture is made with 1¼ ounces of red phosphorus, ½ ounce of dextrine or 3/4 ounce of Lepage's Mucilage (from the dime store) and 3/4 ounce of fine sand. Enough water is added to make a paste, slightly thinner than the black paste.

The striker is a tongue depressor, bought at the drug store, or any similar light, thin piece of wood. A couple of inches of the striker is smeared with the red paste and allowed to dry. The red paste should be stirred well before using as the sand will sink to the bottom after a time.

CHEMICAL DELAY IGNITERS

Chemical delay igniters have always been popular with the more versatile Militants. The most common such igniter, but a perverse one, is the sulfuric acid-potassium chlorate and sugar goody.

The igniter is a mixture of half potassium chlorate and half granulated sugar. It bursts into flame with the application of a drop of sulfuric acid.

The idea is to put some of the mixture into a glass or plastic tube and then stuff in some cotton, or paper. Some acid is then put into the tube with a medicine dropper, bought at a drug or hobby store.

The acid is supposed to seep slowly through the barrier and finally ignite the mixture. The bad thing about this system is that it often doesn't work or it works too fast.

When sulfuric acid eats through vegetable matter there is a reaction of great heat. This is often enough to break the glass tubing or melt a plastic drinking straw and can stop the action right there.

If the glass tubing holds, the acid still loses its potency as it reacts with the vegetable matter and that which reaches the mixture may be too weak.

The worst thing that can happen, however, is that it will work too fast. The acid can eat through the barrier in seconds instead of the minutes you think you have.

This could be disastrous if you loitered in the area for a minute to avoid looking suspicious. If you armed the device before going into the target area, you might not even get there.

To avoid such hangups you should use a non-reactive barrier such as asbestos fibers, bought from any building supply store. The acid will seep through the asbestos without making heat and without losing its potency. And since it doesn't eat the asbestos, it can be timed with much more certainty, which makes it safer and more sure.

Powdered highway flare igniter can be substituted for the potassium chlorate-sugar mixture. It is over half potassium chlorate and is simpler. In fact, if the plastic straw is pushed over a fuse coated with flare igniter, the fuse needs no other igniter.

Another chemical ignition device uses glycerine to react with potassium permanganate. Potassium permanganate is a relatively stable oxygenator and can easily be bought at the drug store. It is also used for staining microscope specimens, disinfecting fish tanks and curing fish fungus and fin rot.

The potassium permanganate is ground to a powder and mixed with the same amount of fuse powder or the highway flare igniter. Cotten can be used as a barrier as it doesn't react with glycerine.

At least an inch of glycerine is put into the tube, especially if you use a barrier. When it reaches the mixture it takes from three to five minutes for the ignition to take place.

For some reason, I haven't been able to get this to work except in a plastic straw. But that way it works every time and is lots of fun.

If the igniter is potassium chlorate and sugar or flare igniter or potassium permanganate, it needs a barrier to keep it in place. To make sure the fire train burns past the barrier to the fuse, the barrier should be flammable. To make material for this barrier, mix cotton with wet fuse powder or flare igniter. Then dry it and pull off pinches as needed.

To arm these devices a medicine dropper filled with acid or glycerine can be carried upended in a test tube in the shirt pocket. A plastic felt-tip marker with a clip to hold it upright in the pocket can be used instead of the test tube. It is simply hollowed out and the dropper fits in nicely.

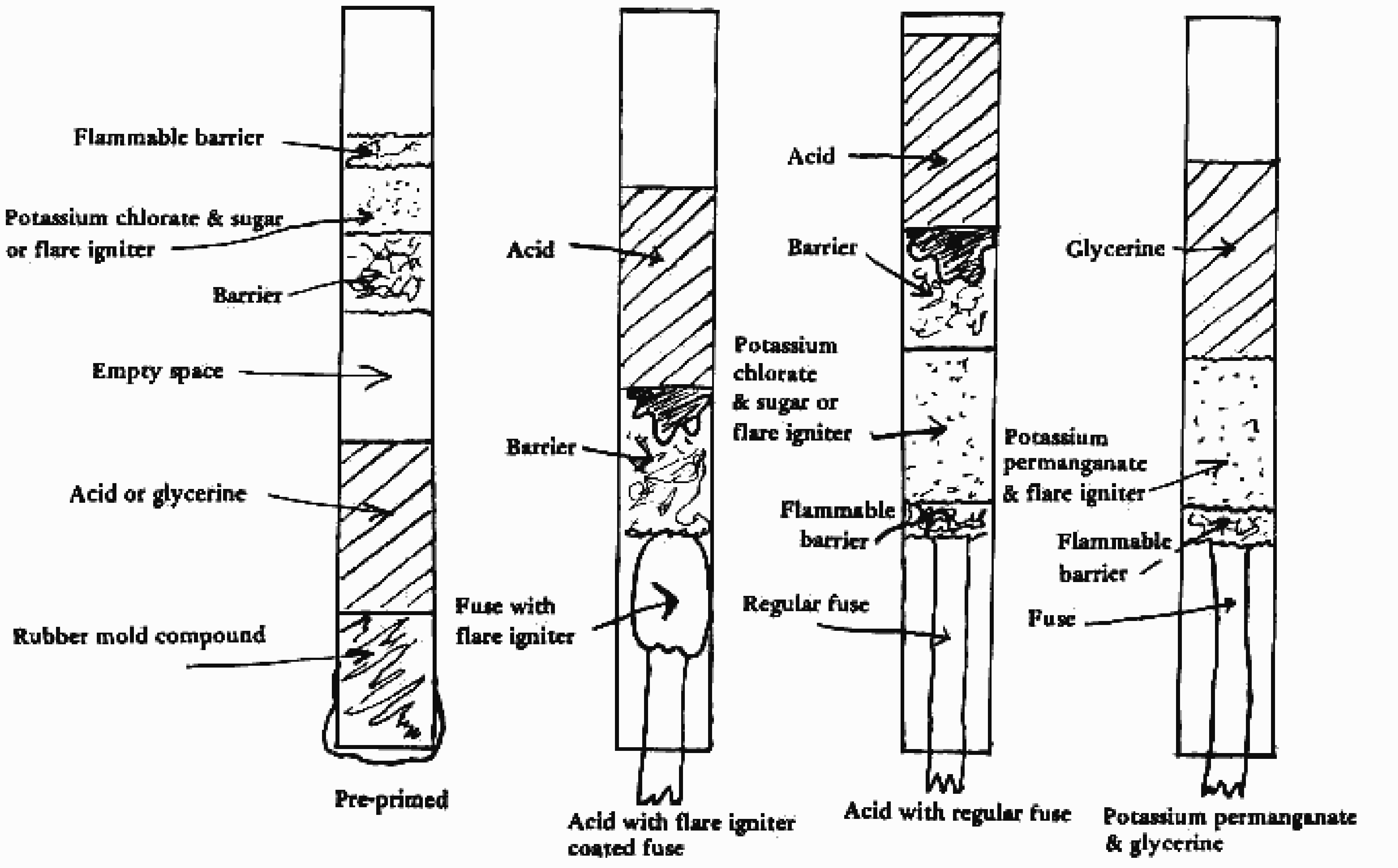
To avoid burned fingers, a string is tied to the dropper so it can be pulled out of the container.

To avoid the medicine dropper entirely, you can make up some pre-primed plastic straws. For these, you will need some rubber mold compound. Suck up a half inch of the compound into a 4½ inch plastic straw. Then let it dry for a couple of days.

Shortly before use, put in the acid or glycerine. Then, with a cotton tipped stick, clean out the straw above the acid or glycerine so there will be none on the sides to ignite the mixture.

Next, put in the barrier and push it within an inch above the acid or glycerine. Then put in the mixture and the flammable barrier.

You can carry this quite safely upended in


Flammable barrier
Potassium chlorate & sugar or flare igniter
Barrier
Empty space
Acid or glycerine
Rubber mold compound
Pre-primed
Acid
Barrier
Fuse with flare igniter
Acid with flare igniter coated fuse
Acid
Barrier
Potassium chlorate & sugar or flare igniter
Flammable barrier
Regular fuse
Acid with regular fuse
Glycerine
Potassium permanganate & flare igniter
Flammable barrier
Fuse
Potassium permanganate & glycerine

CHEMICAL DELAY IGNITERS

your shirt pocket. When ready for use it is turned over and its open end is pushed over the fuse.

BOMBS

Although the wristwatch time bomb is not a formula, I feel that no book concerning bombs and Militants should be without this.

The diagram is strung out to show the points of contact. The igniter is a flashlight bulb, carefully broken to keep the filament intact.

Filaments from household light bulbs can also be used but they are very delicate. The bulb is broken and the filament is removed and carefully attached to the two copper wires.

Improvised goodies are fun and give a sense of creative accomplishment. Even so, an electric dynamite cap will take the place of a lot of ingenuity.

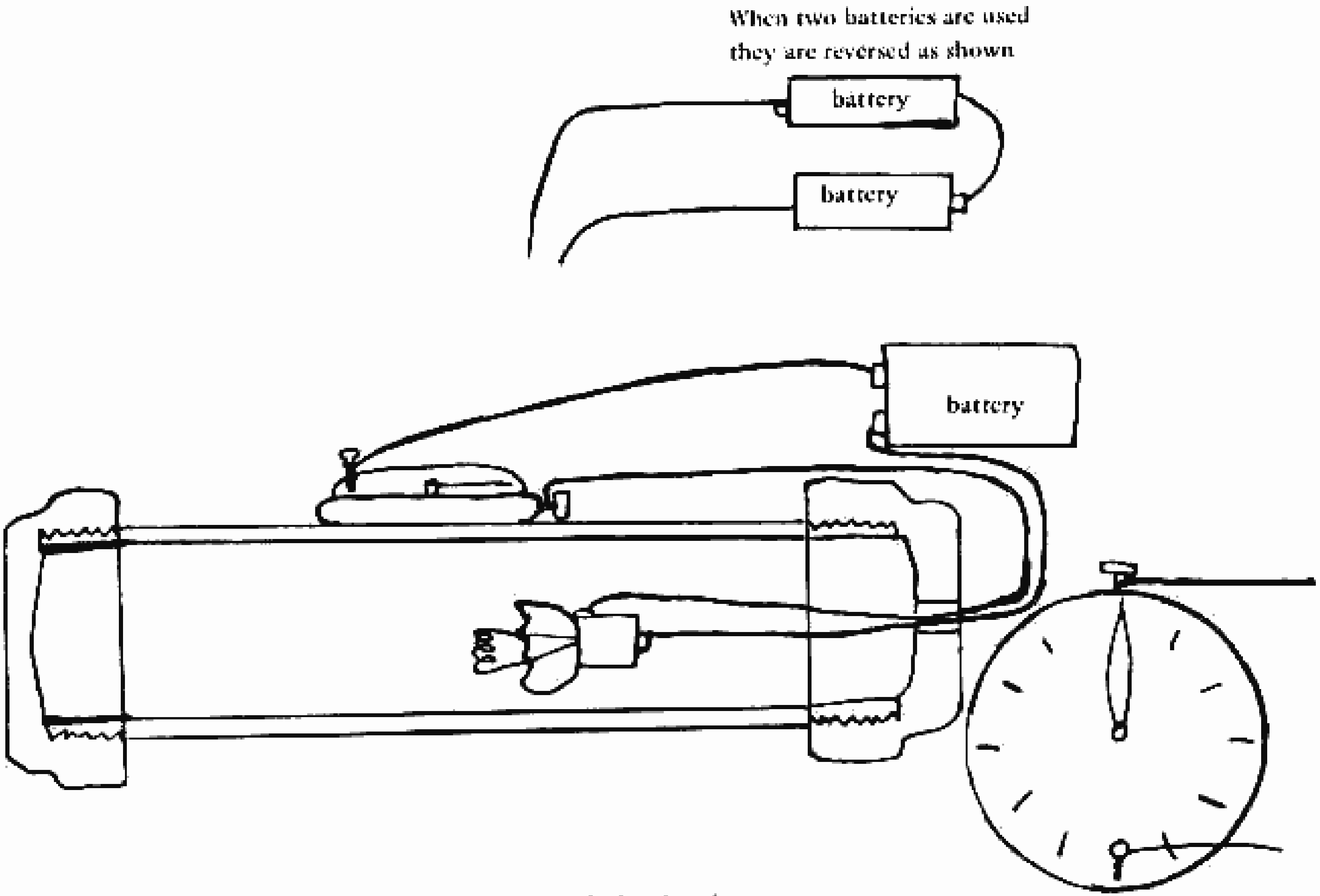
Flashlight and transistor radio batteries are sufficient to heat the filaments or detonate the dynamite cap. If flashlight or pen light batteries are used they should be reversed as in the illustration.

The wires should be soldered to the battery terminals to insure contact. The best wire is the thin, plastic covered kind used in transistor radios.

A hole is drilled into the plastic watch lens and a small nail is inserted and glued in place so its point doesn't touch the watch face.

If the bomb is to go off more than an hour after it is set, the minute hand is taken off.

The watch hand making contact with the nail is sanded to remove any paint on the contact edge.



Wristwatch time bomb

When the bomb is finished the parts are compacted and taped securely to its casing. The watch is secured with transparent Scotch Tape so that the hands are visible for setting.

The watch is allowed to run down before attaching it to the bomb and is wound only after it is set.

To avoid frustration from a dud bomb, the timer, battery and filaments should be tested before arming an actual bomb. This is done by putting the filament into a small pile of powder. If it ignites, disconnect the battery immediately to save the filament. Examine the filament carefully to make sure it is still intact and if it is it can be reused.

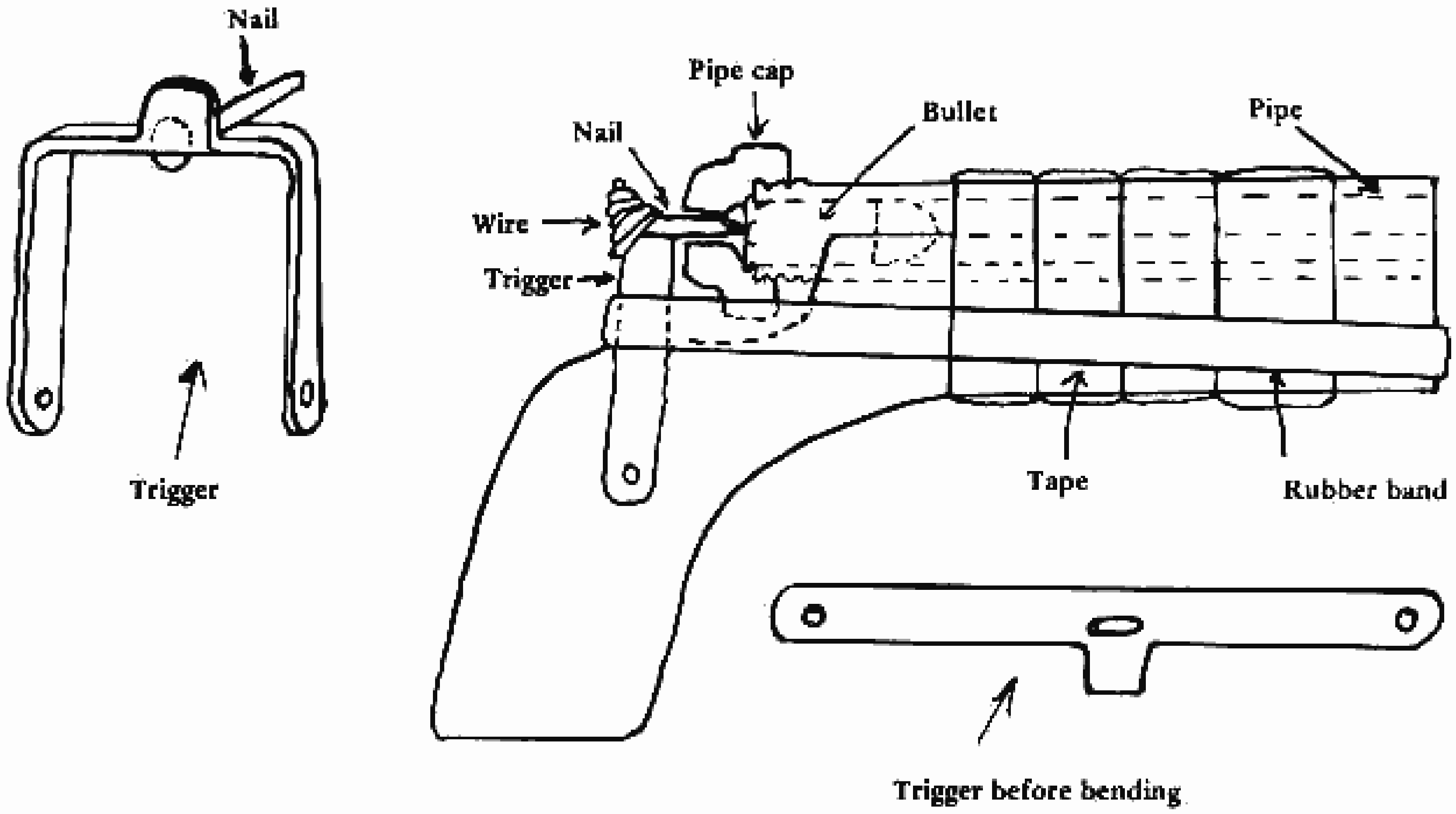
PIPE BOMBS

Pipe bombs, whether filled with match heads, gunpowder or high explosives, should be lined with plastic Baggies or freezer bags. This prevents friction, static electricity and any chemical reaction between the explosive and the metal.

The mouth of the bag is folded back over the threads and the explosive is put in. Next, the fuse is put in and the plastic bag is wrapped tightly around the fuse and held with a rubber band. All this is necessary because any explosive on the pipe threads could cause the bomb to explode when the cap is screwed on.

The cap for the fuse hole is drilled from both sides with any high-speed steel industrial twist drill bit. The bit is used with any electric hand or table drill.

The size of the hole should be exactly the size of the fuse. The plastic bag should cover



ZIP GUN

only the lower part of the fuse. Flare igniter, if used, should be put on the fuse after the cap is screwed on as the hole would have to be made larger than necessary to accommodate the glob of flare igniter.

PIPE OR "ZIP" GUNS

Commonly known as "zip" guns, guns made from pipe have been made and used for years by juvenile punks. Today's Militants make them just for the hell of it or to shoot once in an assassination or riot and throw away if there is any danger of apprehension.

They can be used many times but with some, a length of dowel is needed to force out the spent shell.

There are many variations but the illustration shows the basic design.

First, a wooden stock is made and a groove is cut for the barrel to rest in. The barrel is then taped securely to the stock with a good, strong tape.

The trigger is made from galvanized tin. A slot is punched in the trigger flap to hold a roofing nail, which is wired or soldered onto the flap. The trigger is bent and nailed to the stock on both sides.

The pipe is a short length of one-quarter inch steel gas or water pipe with a bore that fits a cartridge, yet keeps the cartridge rim from passing through the pipe.

The cartridge is put in the pipe and the cap, with a hole bored through it, is screwed on. Then the trigger is slowly released to let the nail pass through the hole and rest on the primer.

To fire, the trigger is pulled back with the left hand and held back with the thumb of the right hand. The gun is then aimed and the thumb releases the trigger and the thing actually fires.

Pipes of different lengths and diameters are found in any hardware store. All caliber bullets, from the .22 to the .45 are used in such guns.

Some zip guns are made from two or three pipes nested within each other. For instance, a .22 shell will fit snugly into a length of a car's copper gas line. Unfortunately, the copper is too weak to withstand the pressure of the firing. So the length of gas line is spread with glue and pushed into a wider length of pipe. This is spread with glue and pushed into a length of steel pipe with threads and a cap.

Using this method, you can accommodate any cartridge, even a rifle shell. The first size of pipe for a rifle shell accommodates the bullet. The second accommodates its wider powder chamber.

A 12-gauge shotgun can be made from a 3/4 inch steel pipe. If you want to comply with the gun laws, the barrel should be at least eighteen inches long.

Its firing mechanism is the same as that for the pistol. It naturally has a longer stock and its handle is lengthened into a rifle butt. Also, a small nail is driven half way into each side of the stock about four inches in front of the trigger. The rubber band is put over one nail and brought around the trigger and snagged over the other nail.

In case you actually make a zip gun, you should test it before firing it by hand. This is done by first tying the gun to a tree or post, pointed to where it will do no damage. Then a string is tied to the trigger and you go off several yards. The string is then pulled back and let go. If the barrel does not blow up, the gun is safe to fire by hand.

You should not attempt to register such a gun.

HOW TO BEAT A METAL DETECTOR

Many Militants squirrel away stockpiles of guns and bombs and as fast as the authorities find them with metal detectors, the Militants discover new ways of fooling the metal detectors. Militants hiding lethal goodies have discovered the following tricks to fool the detectors.

Rural Militants bury illegal items under metal scrap piles or where garbage with tin cans has been thrown for years. There is so much rust and bits of metal in the soil that the detector indicates that a tank is buried there.

Not believing there is a tank buried there (although there might be) the searcher moves on to find a more localized, and therefore easier, digging job.

Iron filings and lathe cuttings scattered over the site will give the same false readings. The agent using the detector will figure he is over a dump site or an iron mine. Unless he can con some archaeologists to dig up a few hundred cubic yards of dirt he is apt to just wander off and get blind drunk.

The floors of barns, being impregnated with iron-containing urine and excrement from the animals, render metal detectors useless.

Fence corners and other places where animals gather regularly are good places to bury contraband since the soil there is the same as that in barns.

Since streams deposit metallic oxides along their courses, a dry stream bed will likewise register a bonanza which no civil service worker will tackle.

City Militants have more space problems than do rural ones. But they still find ways of hiding stuff from detectors. The concrete floor of a basement is a great place under which to hide metallic objects. If there is a way of digging underneath the cement, the objects are safe from the detector. It will buzz everywhere and not pinpoint anything.

Those lucky enough to have a basement space to build a secret room are least likely to be found out. Walling off a corner of the basement makes a dandy goody hider and can also hold a body or two.

If the basement walls are made of reinforced concrete, that is, has those steel rods embedded in them, the new wall must give the same metallic reading. To achieve this, the mortar cementing the bricks is liberally sprinkled with cut soft wire in about one-eighth inch bits or a few handfulls of tiny wire nails. None is put into the mortar used to cover the brick wall. In this way, the brick and the concrete will measure the same metallically.

Whether the secret compartment is walled with metalized mortar or is just a plain brick wall, the goodies to be hidden are placed in the middle of the space and not touching any wall.

The poor Militant who has only a little back yard and no cows, garbage or scrap pile has a real digging job ahead of him. He needs a hole five or six feet deep.

The goodies are stored in a wooden box covered with tar or creosote to protect it from the moisture. Then the box is covered around and on top with about a foot's thickness of loose, non-metallic rocks. Next, the hole is filled with dirt.

Smart Militants put a layer of plastic over the rock covered box, since a metal detector works best if damp earth is in contact with the hunted objects.

BLOWING UP A CAR

Those Militants not content to psych out the driver with some practical joke have his last ride in mind.

The best methods require getting under the hood. Explosives are placed as near the occupants as possible. The fuse, homemade, commercial or safety, is wrapped a few turns around the exhaust manifold. After a few minutes on the road the exhaust manifold gets almost red hot and ignites the fuse.

This way is more certain than wiring the car because since it blows up on the road the wreck will do the victim in even if the blast doesn't. Besides, if the intended victim is a passenger instead of the driver, the driver may start the engine before the passenger gets into the car. You can see how embarrassing that would be to the bomber, can't you?

Old-fashioned types, like the Mafia, love to wire cars. They are too set in their ways to change and besides, they get a charge out of seeing a car blow up before their eyes instead of imagining it going to hell on the road.

They usually use about three sticks of dynamite, two lengths of electric wire with two alligator clips for quick attachment, and an electric blasting cap. The cap is stuck into a dynamite stick and its two wires are connected to the two electric wires. Then one alligator clip is clamped to the input side of the coil and the other is fastened to any metal surface in the car's frame as a ground.

This is very simple and you'd think anyone could do it. But sure enough, there are always morons who will attach one clamp to a spark plug and one to a ground. This usually results in misfires and no end of frustrations.

EVADING PURSUIT

Now we go from destroying cars to protecting them and their contents from pursuers. A diagram would fit only a few of the vehicles but this explanation should be understood by anyone at all handy with cars and trucks.

First, a hole is drilled in the exhaust manifold the size of the nozzle of a paint or plant sprayer. When the nozzle is welded in place a length of gas line is affixed to the nozzle tube and fed into the driver's compartment.

The gas line is then attached to the spray unit inside the driver's compartment under the dash.

Solid brass plant sprayers going under the trade name of "Mist"ifier, or similar, can be bought at any garden store. The nozzle is removed and welded to the exhaust manifold and the container is put inside with the driver and connected to the nozzle unit with a length of gas line.

To use, the container is filled with castor oil, bought at any drug store. Burned castor oil will blot out everything on the road behind you.

A friend tried this and just put in a few short squirts to see what it would do. The effect from his exhaust pipe was so wild that it looked like a bomb had been dropped on the freeway.

He was so startled he allowed himself to be pulled over by a cop and he almost got locked up for it. He could have gotten away if he had made a smokey run for it.

It is the hot exhaust manifold which turns the castor oil into smoke. Smoke screens in war are made using this simple principle. Crank case oil to be thrown away is great for smoke screens. It could also highlight the idea of recycling in your area.

On the road, the smoke not only causes pursuers to slow down in order to see, but it causes panic among the other motorists on the road. This makes the police stop the chase as the traffic hazards are greater than your capture is worth.

POISONS

Since this section was written, in 1970, I've run across a terrific book you'll want to get from your library or order through your local book store. It is "Poisons, Antidotes & Anecdotes", by William Tichey and published by Sterling Publishing, 1977.

It is the most fun book and will give you oodles of ideas as well as tell you how poisons work.

Also, I've incorporated "The Complete Medical Student's Manual of Chemistry" into GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY. This manual has the most extensive writings on poisons of any book I've ever seen. Under the headings of "Action on the economy", it describes how much of what will do in an opponent and how he will react and for how long before he croaks.

PLANT POISONS

Plant poisons are very easy to administer and are hard to trace. A few leaves in the salad aren't noticed and the victim dies without knowing why.

Rhubarb, for one, is a deadly poison. The stalks are fine but if you eat any of the leaf, you'll die. Cooked, the leaves take an hour or so, but in a salad they kill almost immediately.

The rhubarb bought in stores has all the leaves taken off so you will have to get the leaves from a farm or grow your own.

You don't have to be stingy with rhubarb and most other plant poisons like figuring grains and grams. Just chop up some leaves and put them in the salad or stew or among the lettuce on hamburgers and you will have hit the jackpot.

Castor beans are a good poison as they are almost tasteless when ground and only three or four are enough to kill. They're easy to get, especially in Southern California where they grow wild. They can be put into almost any food.

Oleanders are common flowers but are about as poisonous as any plant. The heart is affected very quickly and severely. Both the leaves and branches are lethal.

A couple of poinsettia leaves will kill just about anybody. Better use three.

Yew is a conifer, or cone bearing evergreen tree or shrub. Any nursery man can take you out in back and identify it for you. But he will get pretty surly if you start stripping off branches so you should buy a small tree, if you don't know where a big one is growing.

It's the foliage that kills so forget the berries. It is so poisonous and so quick that at one time the Secret Service considered it for suicide pills. The beauty of it is that it kills almost immediately without any symptoms. You take it and, splatt, you're on the floor, dead.

I'm not sure of the dosage but it's not much.

The way to refine it is to fill a coffee percolator with the ground up foliage and put eight ounces of alcohol in the pot. Percolate it for about a half hour. If the alcohol boils off, put in some more.

Cheap rubbing alcohol is good enough once you have distilled it off from its water content.

When the process is finished, put the alcohol and what went through the percolator into the still. You then distill off the alcohol until you have only a couple of teaspoonfuls of residue left. Pour this out into a saucer and let it evaporate.

You can use the same process for a finer grade of nicotine from tobacco. Always strive for quality.

Laurel is another evergreen that can cause death by the eating of a single leaf. It is best percolated and distilled but it can be used as it is and put in stews and as a garnish on hors d 'oeuvres.

Poisoning was a great sport and topic of conversation before the widespread use of firearms. Now that firearms might be going out, Militants and suburbanites are becoming interested in more aesthetic ways to kill.

Unlike your gun, poison is seldom very effective against burglars. But say you've been suckered into giving a wife swapping party where every female but your own is either pregnant or periodic. In this case a little something to sprinkle on the hors d 'oeuvres is a good thing.

The Militant can use poison on individual enemies or can put it in refreshments at rallies of political opponents. It is also great for getting rid of rivals in his own group. Last, but very important, is that old standby for an embarrassing moment, the self destruct capsule.

There are several books on poisons. The best one is POISONS, by Vincent Brooks. It's mainly for doctors and police but is very readable and amusing. Most libraries have it, along with several others, which are mainly about garden plants to watch for.

I got a great charge out of reading about Warfarin on page 108 of POISONS. Warfarin is a rat poison which is mainly corn meal or some other rat dainty. Anyway, it tells how some slob was induced to eat a pound of it a day for six days. Talk about Jethro Bodine!

A word to the wise; if you're a southern type and your wife stops eating her share of the corn pone, thrash her and make her eat all the pone.

Poisoning is no pastime for an idiot. You've got to be mighty shrewd. To give a blood enemy just a bad taste in the mouth while you're sitting talking with him over a drink is dangerous. He'll suspect poison and know you tried to do him in.

Poisons act in different ways. There are four considerations when selecting a poison. Four effects for different objectives.

One objective might be to kill the victim immediately so he would be unable to talk. Another would be a several minute delay where the victim would be stricken some time after you had left the scene.

Still another consideration is that the victim should be unconcious so he can give doctors as little help as possible. Also, you don't want him to hurt any more than necessary because that would be mean. The fourth consideration is that the dose is strong enough to be lethal.

As you apply yourself to this study you will occasionally blunder. Your victim will be down, flopping like a fish off the hook and the medical types will still pull him through. I know this is frustrating, but one must learn to cope.

Another good thing to know about the poison of your choice is its legitimate use. If a druggist or someone else asks you what you want with it, it's embarrassing to have to admit that you want to kill someone. A cover story is always good.

ETHYLENE GLYCOL

This is simply antifreeze, such as Prestone, Zerex, etc. Always read the can to make sure the ingredient is ethylene glycol. It is a colorless, syrupy liquid with a sweetish taste. It mixes well with both water and alcohol.

Authorities disagree on the lethal dose. They put it from a half ounce to four ounces. This is not important, however, as anyone will drink four ounces in his soft drink without becoming suspicious.

It can also be tasted along with what you've put it in. Just wash your mouth out and you will feel no bad effects.

At a party, a half-gallon at a time can be dumped into the punch bowl so that everybody will get his share. Only don't pour it in directly from the anti-freeze can. An observer might wonder about you. Instead, put some food coloring or Kool-Aid in it to make it look like grape juice or something and put it in two-quart fruit juice cans.

That way you can pour it in the punch and stir it and grin and anyone watching would think you were just helping.

A nice thing about ethylene glycol is that a person dying from it just seems drunk.

ARSENIC

Arsenic and its compounds are great poisons. They are quite popular and have been a good subject for comedies such as "Arsenic and Old Lace." The nice thing about arsenic is that it is almost tasteless and it doesn't start to act until a half hour to an hour after it is taken. That way you can zap just oodles of people who would get off scot free if you used a fast poison like cyanide. Cyanide is terrific for individual hits but disappointing when working with groups.

Say you're operating at a governor's banquet and you lace the grits with cyanide. One of the victims would be eating a handfull of grits and would all of a sudden flop over into his gravy. His neighbor might swipe his pork chop but you can be sure he would not touch the victim's, or his own, helping of grits. He might even warn others.

But with arsenic, they'll all be to their prunes by the time the poison takes effect.

The lethal dose of most arsenic compounds is from 0.1 to 0.5 gram. A gram is only 1/28th of an ounce. Say you had a pound of arsenic or arsenic trioxide, etc. Say, also, you allowed the maximum dose of half a gram. That would be 896 fatal doses. There would be enough left over to take care of the Senate and Congress and even Billy James Hoggis.

SODIUM FLUORIDE

This is rat and insect poison. It's a real killer. It can be bought at hardware and garden stores in an adulterated powder. Chemical supply companies sell the pure stuff for $.35 an ounce.

You can make it yourself with hydrofluoric acid and sodium carbonate (sal soda).

Use only plastic when working with hydroflouric acid as it eats glass and metals. Also work with good ventilation and avoid the acid fumes.

Put one part sodium carbonate in a plastic container and add an equal amount of acid, slowly, stirring all the while. The result will be colorless crystals and white powder.

Death has been caused by less than one grain. There are 437 grains to an ounce so a grain would be about the size of a grain of rice or wheat.

In case you didn't know, sodium flouride is the waste matter from certain chemical companies which they unload on moronic city officials, like those in Eureka, to fluoridate the drinking water. It might toughen kid's teeth but it also dulls the creative part of the mind, even at one part per million in drinking water.

POISONS doesn't say if the full strength stuff is fast or slow to act or how long the victim lasts. Testing is in order here.

NICOTINE

Nicotine is a really terrible poison. One drop of pure nicotine has killed in fifteen minutes. It is great to put a few drops in an opponent's shot glass and make a bottoms up toast to Senator Fulbright.

Its taste is pretty well covered by wine, especially sweet wine. It's not so good in drinks that have to be sipped and savored. Few poisons are.

You can get almost pure nicotine from the kind of snuff that comes in round, flat boxes. Pour it out into a water glass and put in just enough water to cover it all.

After about 24 hours pour the mess into a handkerchief that has been stuffed down into another glass but with its edges over the rim. Then lift out the handkerchief and twist the edges so that the snuff forms into a ball. Continue twisting until all the liquid is squeezed out.

Pour the liquid into a small sauce pan and put it on a low fire. When the liquid has evaporated to about a teaspoonful of thick syrup it is finished. It is best to dilute it with enough water so it will easily leave a medicine dropper. A few drops should do the trick.

A good way to handle nicotine is to fill a medicine dropper with it and plug the end with a piece of soft wax which is pushed in and molded around the opening. The dropper is carried with the wax end up in the shirt pocket and is ready for use in a jiffy.

Nicotine is also a good way to commit suicide if you are a prisoner. Just collect a handfull of cigarette butts and strip the paper from them, if you are a neat person.

Soak them for several hours, if possible, in water. If you are being watched you can slip them into your coffee. At the last minute just gulp the whole thing down. Best to do it on an empty stomach. If you keep your mouth shut for a few minutes, even if they pump you out it will be too late.

Nicotine is an alkaloid so you might get quite a high while you die. Give it a try.

NICOTINE SULFATE

This is my favorite. It is an insect poison found under several brand names. The most common is Black Leaf 40, bought at any garden store. This stuff is 40% nicotine sulfate. Just a few drops in a drink will kill quickly.

It is best to evaporate it to the point where it is like a thin syrup and will still form into drops from a medicine dropper.

One of the glories of nicotine sulfate is that it is absorbed by the skin and is fatal within a few minutes. Death by nicotine sulfate can only be detected by a blood test, which is seldom given.

A fine way to use nicotine sulfate is to carry it in a soft drink cup and act like you accidentally spilled it on the victim. If he doesn't wash it off in a matter of seconds he will be dead in a matter of minutes. There is little chance of him washing it off if he thinks it's just a soft drink, especially if he is at a meeting or talking to someone.

Most other insect sprays and powders kill by being absorbed through the skin. Some of them are: Malathion, Parathion, Chlordane and Lindane.

TESTING POISONS

At first thought it would seem that the best way to test poisons would be on alley cats. Cats are not the best subjects because, first it's naughty to hurt cats and also because they are hard to kill.

Alley cats eat such garbage and corruption they develop cast iron stomachs. A cat can often handle a dose that would kill a dozen people.

The best subject is a wino. In every city there are hundreds of winos sleeping out in nests in vacant lots, abandoned houses, under bridges, etc. It's very easy to find such nests. They are usually made up of flattened cardboard boxes and newspapers and littered with wine bottles.

Put the dose you want to test in a half full fifth bottle of sweet wine. Then tuck it in the nest where the wino will be sure to find it. He will just think another wino hid it there.

If the nest has a dead wino in it the next morning you've figured out the right dose. If both the nest and the bottle is empty, it's back to the old drawing board. Try increasing the dosage.

I was going to test poisons myself in this way. Then I realized I would probably wipe out half the Eureka City Council. Even so, they deserve it, since they all voted to put sodium fluoride in the city's drinking water.

Most poisons can be tasted to see what, if any, flavor should be added to hide the taste. It's quite safe to put a little bit on your tongue to get the taste and then wash your mouth out well. The only poisons I would not taste are prussic acid and others that kill with less than a grain and strong acid or lye which would damage the tongue.

The safest way to test poisons, for you, is to put it in dope. Another safe way is to put it in an enemy's medicine. If you have access to his bathroom look for capsules, especially prescription so you know he's the only one taking them.

I saw the capsule trick on "Ironside." Clever.

Care every step along the way makes the difference between the proud expert and the red-faced bungler. Imagine the embarrassment of the ancient Greek poisoners when Socrates said, "Wow! It sure doesn't *taste* like tomato juice!"

COUNTERFEITING

Many Militants rob banks for operating expenses. It is pretty easy to get caught and go to jail for ten years, that is, if you don't get shot and killed. Counterfeiting is a lot less risky and the sentence is about the same if you are caught passing funny money. Also, there is less danger of harm.

Ninety per cent of the arrests for counterfeiting are made on tips. If you are a lone wolf and produce the stuff all by yourself, and if it is pretty good, your chances of capture are very slim.

If there are two people involved the chances are two to one against you. If there are three people, it's three to one and so on.

The person I got this information from made the best stuff the T-Men had ever seen. He wasn't caught making or passing it. He was suckered.

The treasury people are setting up all kinds of fun and games because they are running out of work. They promise to pay informers on tax cheats, but they don't live up to their promises so people have stopped informing.

So, having nothing better to do, they approached this ex-counterfeiter and promised him $20,000 in real money to print them up a million in phoney hundreds. They then showed their badges and arrested him. They have no case since they set him up but he was mad enough to divulge the secrets of his craft.

Anyone who is good with photography and darkroom techniques can be a professional counterfeiter.

This method works, with minor variations, for any paper money from any country. I stress foreign currency because it's a stupid bird that fouls its own nest. But think of a grand tour of Europe, financed out of your own basement. It would do your head good and besides, they want your trade.

Samples of foreign currency can be bought from most coin shops, foreign exchange shops and from many of the larger banks.

Contrary to popular opinion, you can buy paper nearly identical in feel and weight to legal bills. It can be bought from any paper house in the U. S.

It is normally a 25% rag. If you go any higher in the rag content it feels too soft, whereas the 25% has the crackle that a real bill has.

The only problem with the paper is that it is absolutely white. A real bill is not white. It's a combination of greenish, yellowish brown in a very light tint. At the end of the process you have to dye the bills with the tint that matches the real U. S. currency. Foreign bills have different tints.

To begin with, you must have an excellent negative. The first way is to make the bill in the negative the exact size of the real bill. The other way is to enlarge it to about four times its real size, retouch it, then reduce it to its real size.

On U. S. currency, and particularly the 20 dollar bill, there is one very troublesome place. That is around the eyes. Some way, they have made this area very difficult for a camera to pick up.

A plate for currency is made by engraving. They take a piece of flat metal and scribe indentations in the metal. Around the eyes are very fine lines and the indentations around the eyes are very shallow.

There is very little ink in that area. Whenever it is to be reproduced by a photographic process, these lines do not register well on the negative.

Therefore, you must retouch the negative by hand so as to get these fine lines. The easiest method is to enlarge the image to twice its size or more. After the lines are put in, the image is reduced to the exact size of the real bill.

All bills are better enlarged but a twenty is the worst as far as reproduction is concerned. They have made it that way purposely because the twenty is the best denomination to pass. The easiest to duplicate is the hundred dollar bill.

Each bill needs three different negatives.

One negative is for the back, which is all one shade of green. Another is for the portrait side and is for the black. The last is for the green seal and serial numbers on the portrait side.

After you have the negatives for the back plate and the portrait plate you have two very difficult areas. The first is the little green seal reading THE DEPARTMENT OF THE TREASURY 1789. This is on the right side of the portrait.

The denomination of the bill is printed in fine black lines over the seal. These have to be touched out of the negative of the seal and the serial numbers. You have to enlarge the portrait side maybe four times its size and take out all the black parts especially the fine lines through the seal. Then it is reduced to normal size.

Then you take another negative of the portrait side and blow it up about four times. In this one you touch out the seal and the serial numbers. Then reduce it to normal size.

Now you have a complete set of negatives. You've got the green back side. You have the black portrait side without the seal or serial numbers. Then you have the green seal and the serial numbers on the right and left sides of the bill.

Next, you take the three finished negatives and reproduce them so you will have as many bills as your press handles on one sheet. If it handles 8½ by 14 inch paper you will need five of each negative.

Now it is time to get the negatives ready for the plate making operation. You will have to do the printing yourself as it would be risky trying to get a commercial shop to do it for you.

You can get a second hand 8½ by 14 offset press for about $300. You can get a simple book on running the press and describing the offset process from any printing supply company.

To get the negatives ready for the plate making they are cut to the exact size of real bills on the sides but with extra negative on the ends. Then you take a piece of opaque orange plastic and cut a hole in it exactly the size of the several bills.

Next, place the negatives side by side over the hole and scotch tape the ends to the orange plastic. This is called stripping.

Your next step is to lay the stripped negatives down on a sheet of light sensitive aluminum called a lithographic plate. It is best to have a vacuum frame so the negatives will be pressed uniformly on the plate. Then the plate is exposed to an arc light for from two to two and a half minutes.

When the exposure is complete, the plate is put into a sink for developing. First, a desensitizing solution is rubbed over the entire plate. Then the lacquer is put on. Places that were sensitive to the light pick up the lacquer, showing what you have.

When the plate is developed and lacquered, a solution of gum arabic is rubbed on the plate. This prevents moisture from oxidizing the aluminum plate.

When it is ready the plate is put on the press and wrapped around the cylinder. The relation between the position of the paper feeding through the press and the plate on the cylinder is called the register. The register must be exactly the same for all three sets of negatives so there is no overlapping and the printing is perfectly centered around the edges on both sides.

Then the printing starts. The colors on a bill are easy to match. Three inks are used; black and two shades of green. When matching inks you must consider that at the end of the job you will add a tint on both sides. Thus, the greens should be a bit lighter as the tint will darken them.

After the black plate is run it is left to dry for about two hours. Then it is turned over and the green side is run. When this has set a couple of hours it is turned over and the seal and serial numbers are printed.

There should be several sets of serial numbers. When a bill is being passed, one number is good for about a week before it is picked up and listed with banks and stores. A dozen different numbers should be made into negatives for a sizable printing.

When the three colors have been printed and the last is dry, the bills are cut apart with a power paper cutter.

(In the original text the counterfeiter recommends cutting after the printing is done and before tinting. I don't know why. It seems much easier to first tint and iron the sheets flat and then cut. There may be a reason for his sequence so I have followed his text. Another thing might be confusing; and that is in drying the printed sheets for two hours. The impression is given that the sheets are dried individually. Actually, you can stack them as many sheets high as the press permits. Only don't disturb the stack until it has set a couple of hours)

After printing you have what looks like play money with no resemblance in color or feel to real money.

The tint is a combination of yellow, green and a tiny touch of orange. It is a vegetable dye used in coloring cakes, icings and cookies and is bought at any grocery store. You can buy a little package of four different colors for $.35. This is enough to tint five thousand bills.

To make the tint you put water in a pan and carefully add the dyes while stirring. Hopefully, the tint will be too light and can be darkened gradually because if it is too dark you will have to pour it out and start over.

You will have reject bills so test the tint on them. To test, dip the bill in the solution, then press it between two layers of paper towel to blot up the excess tint. Then the bill is dried in a hot oven for about a minute and compared for color to a real bill, preferably a crisp, fresh one.

When you have arrived at the right shade of tint, do the whole batch, blotting like with the test bills and drying in a hot oven for a minute. After this it looks quite similar to a real piece of currency. But that is not the end of it.

The bills should look used. First, they are wrinkled a little. Then they are rubbed with ground coffee to give them an aged, dirty look. Then they will pass even at banks.

Don't worry about the lack of fine blue filaments in your product. Just observe some poor, harried shop broad servicing a line of impatient noontime shoppers and see if she examines the bills for tiny blue filaments. If she did she'd be fired if she wasn't torn to pieces by the mob.

BOMB HANDLING AND PROTECTION

As much fun as bombs are to use against others, most of the fun goes out of it when they are used against you. Whether you represent the government, the Bank of America or a rival Militant group, you may someday need this section so pay close attention.

By far the best work on bomb handling is Lenz's Explosives and Bomb Disposal Guide. This is described in the book section. It is heavily illustrated and is much better than my book for the identification of bomb components and bomb dismantling.

Lenz's only shortcoming, however, is his seeming preoccupation with taking the nasty things apart. My methods are safer and more practical.

If you are confronted with a bomb the best thing to do is to run and report it and so pass the buck to someone else. If you are the one to whom the buck is passed you aren't supposed to run away. You are supposed to make the area safe.

If you are a bomb squad person your first act should be to assure minimum damage in case the bomb goes off before you can dispose of it. Having done this you must next remove the bomb from the area.

If the bomb is obviously going to go off within minutes you may have to deactivate it on the spot. For this I again refer you to Lenz's book because if you are in the business you have no excuse for not having his book.

There are four basic types of bombs: shatter, concussion, shrapnel and fire.

Shatter bombs are those relying only on the actual explosive matter to do the damage. These include chemical explosives enclosed in plastic or paper, blocks or molded plastic explosives or bare sticks of dyanamite.

Shatter bombs have a very short radius of damage. Anything from a half ounce or a couple of pounds will only shatter in a radius of a few inches. You have no doubt heard of a soldier stepping on a land mine and having a foot sheared off at the ankle. Then there is the dynamite fisherman who loses only a hand when he holds a stick too long.

Photo shows complete spatula and plastic medicine bottle on left and exploded spatula on the right.

The photograph shows a spatula which had been used to stir a mixture of about ½ ounce of potassium chlorate and a bit of red phosphorous. The mixer was ignorant of the fact that these chemicals together, stirred dry, will detonate spontaneously.

The resulting blast kneaded the spatula out of shape. It atomized the first 3/4 inch of the bone handle and split the rest. It shattered the plastic mixing bottle.

The fingers holding the bottle had the flesh blown off the bones and the bare bones had to be amputated. The palm of the hand was turned to hamburger and its inner bones were smashed.

The hand holding the spatula was undamaged except for particles of plastic bottle which pierced the skin.

So the shattering effect, although terrible, was only in a radius of about two inches from the outside of the charge of explosive.

Examine the photos of bomb "expert" Norman Hill. He had been fooling with a bomb the size of a pack of cigarettes and it blew his hand into a bloody mist. Otherwise he was not harmed.

This also shows that the shattering effect was only a few inches and concussion was not a factor here.

The second picture points out his foolishness in previously playing with a similar bomb. Note that he is ridiculously bundled up in the most elaborate blast protective outfit. Yet, assuming this was a similar bomb, his body was in little danger. But his vulnerable hands, the parts of him that are endangered,

are bare!

I saw many such pictures during the recent rash of letter bombings. Bomb squad people would be wearing useless vests and carrying the vile letter bombs in their bare hands. Ignorant!

I don't usually moralize about such things but letter bombs are the mark of a creep and a no-class coward.

First, bombs which usually only cripple are no-class. If you are a Militant, regardless of your feelings now, you will change in time. When you are off on another trip you may regret having some victim still crippled for life and suffering.

A case in point is Rennie Davis. I don't know if he ever made a bomb but he was a high priest of the Yippies calling for the end of the establishment. It is impossible to reckon the damage he encouraged with his anti-government speeches.

Yet he has sensibly outgrown the leftist movement. He is now a spokesman for the fat little Indian degenerate, Guru-Maharaj Ji. I wonder if he ever considers the still crippled police his kind produced when they were so right and all-knowing.

At any rate the letter bomb is the lowest of the no-class weapons. It usually gets some non-involved postal worker or secretary. Anyone so cowardly that he can't deliver his weapon to the target is beneath contempt.

Concussion bombs are those meant to lift and move. These send out a shock wave which pushes out walls, buckles steel tanks and raises roofs. They are usually bare chemical bombs or dyanamite.

Shrapnel bombs are meant to send out bits of metal or other hard debris which will puncture people or objects. This would include a pipe bomb as opposed to a bare stick of dynamite.

Fire bombs are usually containers of combustible liquid ignited by a chemical or fire fuse. They may also be cans or bottles of liquid set off by dyanamite or other explosive.

Having found a bomb, if you aren't sure you can get rid of it, you should pack it around with stacks of tied newspapers. Such simple stacks around the bomb and between it and the target will take up most of the shattering effect. They will also act as an excellent buffer to the concussion. They will absorb a blast that would otherwise blow out every wall in a room.

About ten two-foot high stacks of newspapers carried always in the bomb vehicle should protect a lot of property.

If you are lucky your bomb is loose and is probably not going to go off right away. Your next job is to get it away from the scene.

This is best accomplished by using a carrier made of ¼ inch steel and opened at one end. The carrier's bottom part is swung out and it is lowered over the bomb. The bottom is then swung in toward the bomb, the sharpened edge sliding under the bomb and picking it up.

The carrier is then lifted and taken to the bomb vehicle. The open end of the carrier is held facing the least valuable area while the closed end also faces away from people.

If the bomb is sizable and should go off the carrier will be ruined. But there is much less chance for the officer to be injured than without the carrier. The carrier will be jerked from the officer's hand and sent in the direction of the closed end. The main effect of the blast would go out the open end.

That carrier can be made by any blacksmith, boilermaker or welder who works with ¼ inch metal sheeting. The price is around $50.

The design shown is simple and can be made in a few hours. Any metalworker can understand the plan and may even improvise improvements.

A steel rod is welded to the back of the bottom part. It goes through a hole drilled into the top part and is bent over the handle as shown. The rod is also secured to the inside back of the carrier by a welded band.

A half inch extension is welded to both sides of the bottom of the front and the middle of the back. The weight of the carrier rests on these extensions. The bottom, which is actually a large blade, rests alone and swings free of the extensions.

In case you have carried the bomb out to the bomb vehicle and packed it in amidst bundles of newspapers you are pretty safe. The next thing to do is take it to an empty space and shoot it.

It is ever so much fun to stand off and bang away at a bomb with a shotgun. Use 0-0 buckshot. Most likely the bomb won't explode but shooting it to pieces is far more relaxing than interrogating winos.

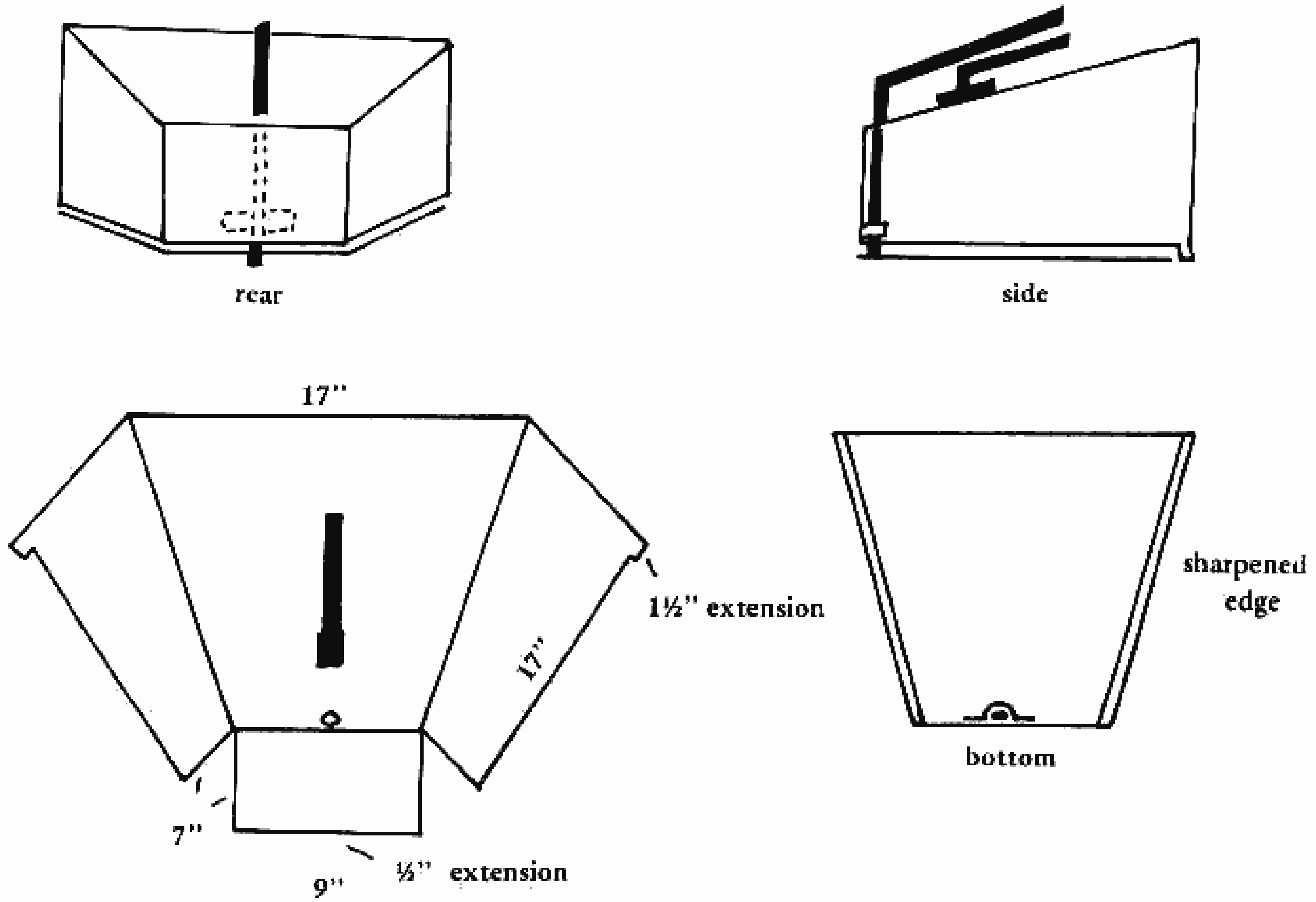
I can't see any reason for taking a bomb apart unless it is about to go off and is chained to an important target. But in case you *have* to disarm a bomb you should have a pair of galvanized hand protectors.

These goodies would have saved Norman Hill's hand and that fellow stirring the chemicals wouldn't have even lost a fingernail.

I don't encourage making explosives but if the manipulations were performed with these hand guards the most potent explosives could be made safely in batches under four ounces. It almost goes without saying that the homemade face and body armor described further on is a must.

Any amateur can make a pair of these hand protectors in an afternoon.

First go to a sheet metal shop and buy two 19½ by 9 inch pieces of galvanized sheet metal. Then get a pair of tin cutters, some picture hanging wire and a 1/8th inch drill.



STEEL BOMB CARRIER

From a drug store buy two pairs of crucible tongs and dip their ends in liquid rubber bought at any hobby shop. About four coats, well dried after each dip, should make the tips so they can be used to manipulate the finest wire.

First cut the sheets in half circles of 19½ by 9 inches. Cut a notch 1¼ inch deep by 2½ wide 8½ inches to the right of the right hand one and to the left of the left hand one. At the appropriate ends of the notches cut smaller notches ¼ inch deep by 1 inch long.

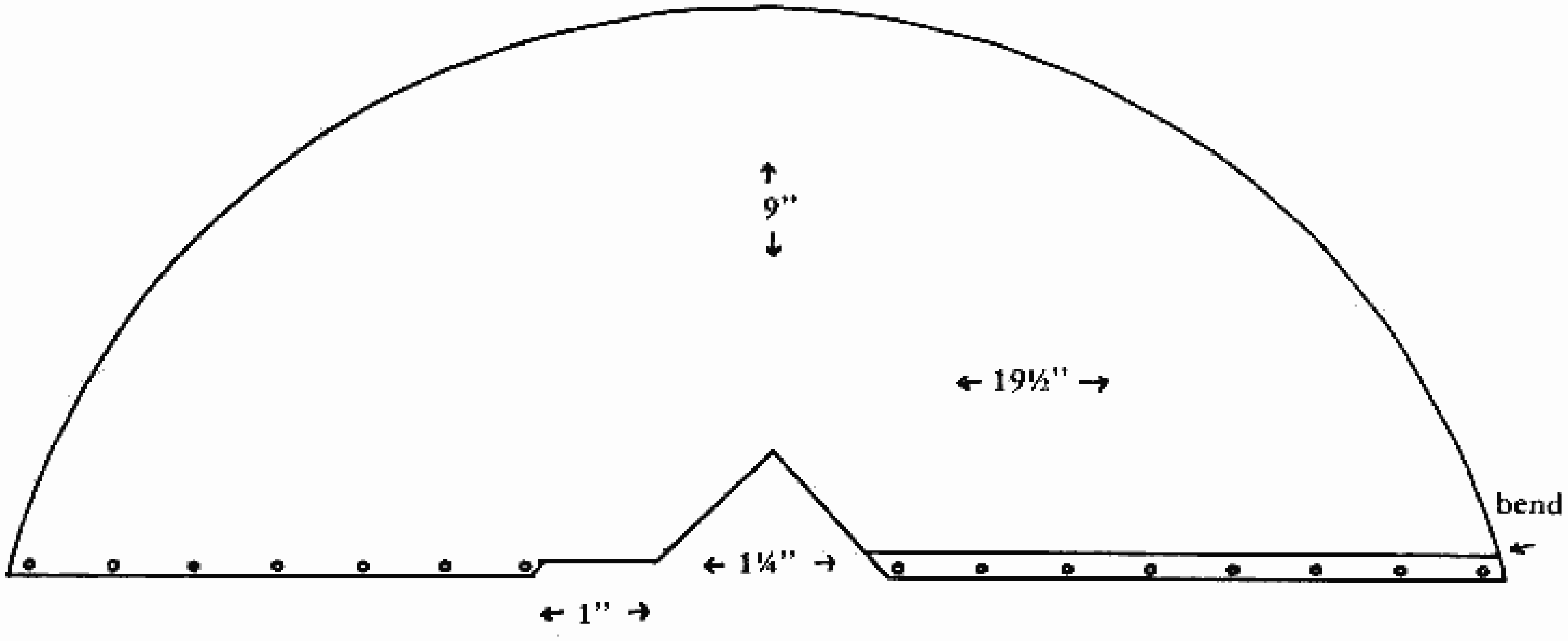
Next, drill seven 1/8th inch holes in each side of the notches. Then bend the drilled edge opposite the small notch to a V.

When the bending is done you next lay the tongs on the metal and bend the half circles entirely so that the drilled edges join and one edge is in the V bend of the other. Then stitch the picture hanging wire through the drilled holes and the job is done.

Holes can be drilled around the rounded edge to accommodate wires holding elastic circlets. In this way the protectors will hang on the wrists without the need to grasp the tongs. You may not think such circlets necessary so they are optional.

When brought to full width the tongs will handle the largest pipe bombs. Even so, I recommend using the carrier for pipe bombs and any other explosives with fragmentation sheathing.

The hand protectors will withstand ever so much concussion but an exploded pipe bomb would give you a couple of pretty battered hands. Therefore, a pipe bomb should be



GALVANIZED HAND PROTECTOR

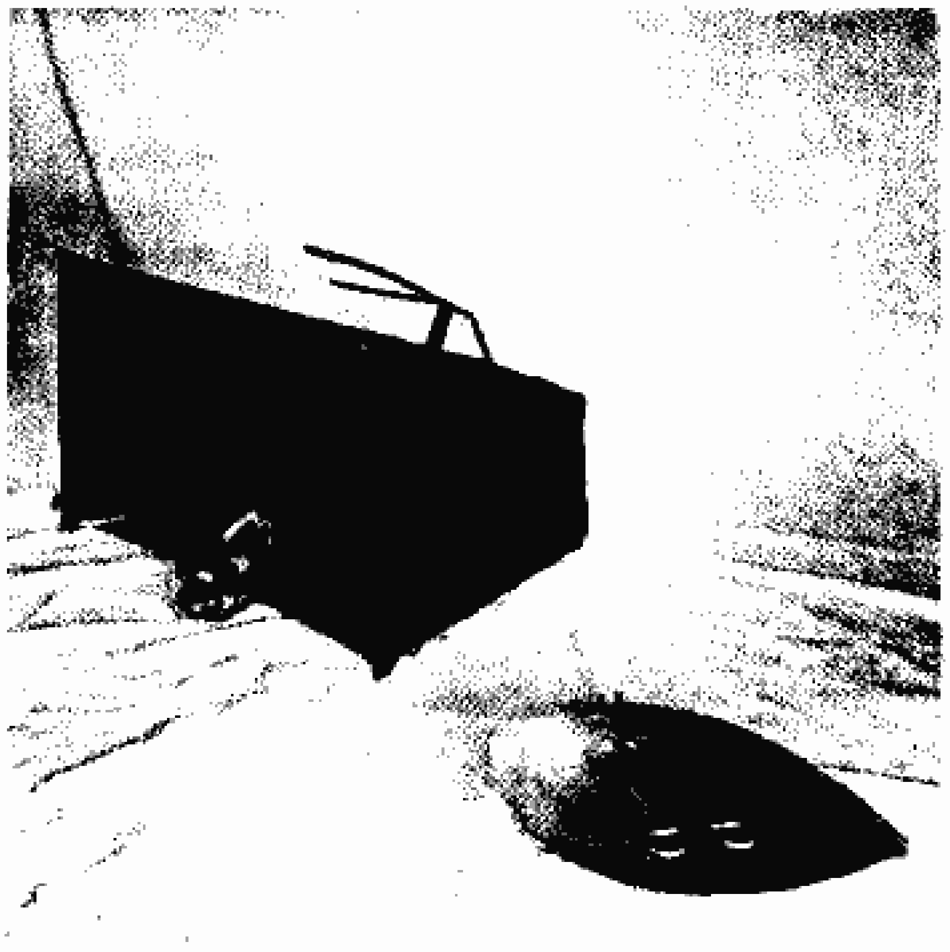


Photo shows galvanized hand protector and steel bomb carrier.

handled only long enough to get it into a carrier. If you must use your hands then the protectors would certainly be better than nothing.

The elaborate bomb suits shown are very expensive but easy to duplicate. They are mainly fiber padding to absorb the concussion and any bits of shrapnel.

Instead of spending up to $300 for a bomb suit a fireman can make his own for $5.00 if he is at all handy or has a wife.

All you need is a pair of coveralls with a slit in the back. As in the illustration you sew on pockets made from blue jean material, reaching around the legs and arms and on the upper and lower torso. In these pockets go tightly packed newspaper at least two inches thick.

For the head you will need a curved piece

of galvanized metal with eye holes. A complete pocket is also made for the head. An inch thickness of paper is put in front of the face plate. Eye holes are cut out as well as a slot for the nose.

A ¼ inch strip of clear plastic is glued over the eye holes of the face plate. Then an inch more of paper with eye holes is slipped in back of the face plate.

An elastic strip sewn to the face mask and going over the top of the head is joined at the back by one sewn to the sides.

Such a suit can be carried in back of a fireman's car and be slipped on much quicker than the many-strapped and buckled examples shown here. I believe they were designed for going in after gunmen.

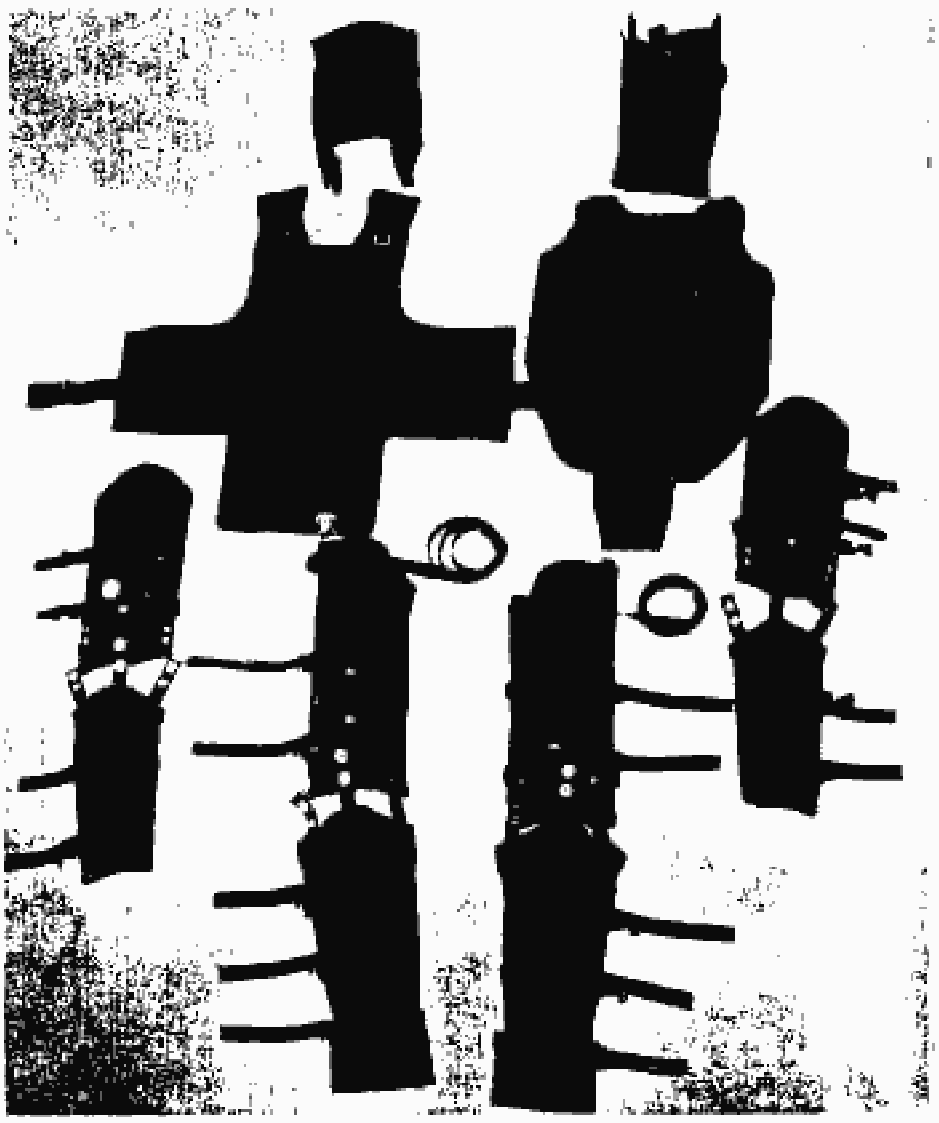
The thirty-five buckles and snaps would take several minutes to put in order. This detracts from the fantasy of the heroic bomb squadder with only seconds to prepare to disarm a ticking monster. Actually, most bombs are dormant when found. They didn't go off as planned and the only real risk is that they will still go off accidentally.

The fact that my suit is Mickey Mouse and cheap should not discourage you. It will absorb one hell of a concussion and a lot of shrapnel. It will be ruined and need replacement but you will probably walk away.

It is certainly as good as the other padded suits shown. The suit with all the straps does not seem to be padded but instead seems to be made of metal plates. This would not absorb a concussion or shrapnel.

Its safety factor would lie in its overall impenetrability. Wearing it, you might not be pierced but would probably get knocked down. And it would certainly be very heavy. I prefer the padding and I think padding is most common.

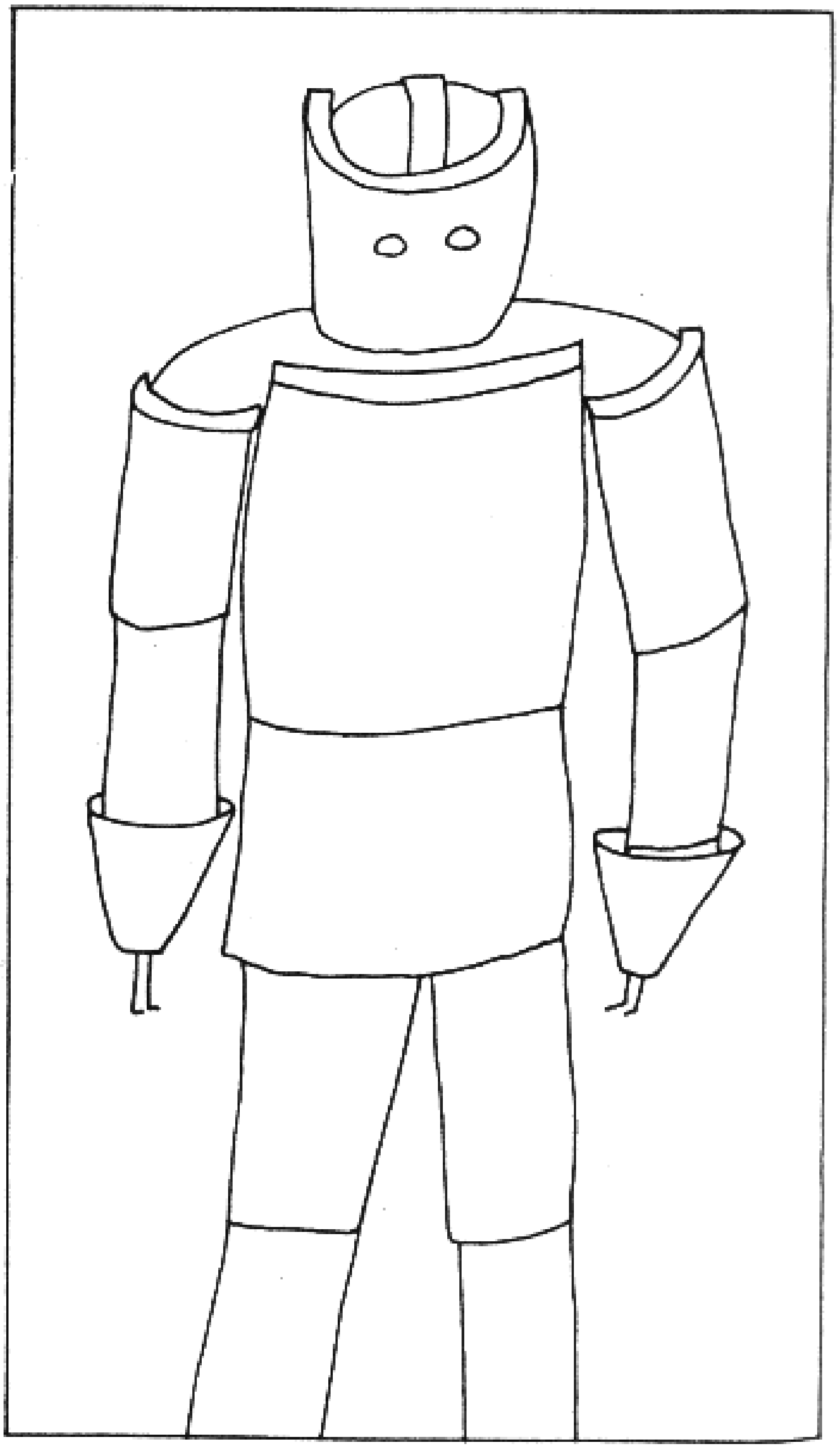
At any rate you can see that bomb disposal is dangerous but not mysterious. You should read Lenz's book and just hope for those ro-



mantic jobs, like on TV, where the clock hand is about a minute away from WHAMMO!

Most properly made and activated bombs go off before they are found. What you will most likely get are duds. Don't short yourself on knowledge, however. But don't go overboard on elaborate equipment, either.

The main reason for making your own equipment is that you will have more confidence in it. It is also cheap enough that you can take it out in the woods, tie it to a tree, and test it against various blasts. You can't get such knowledge when you are assigned the expensive gear.



Handmade Bomb Protection Suit

THE CENTRIFUGAL GUN

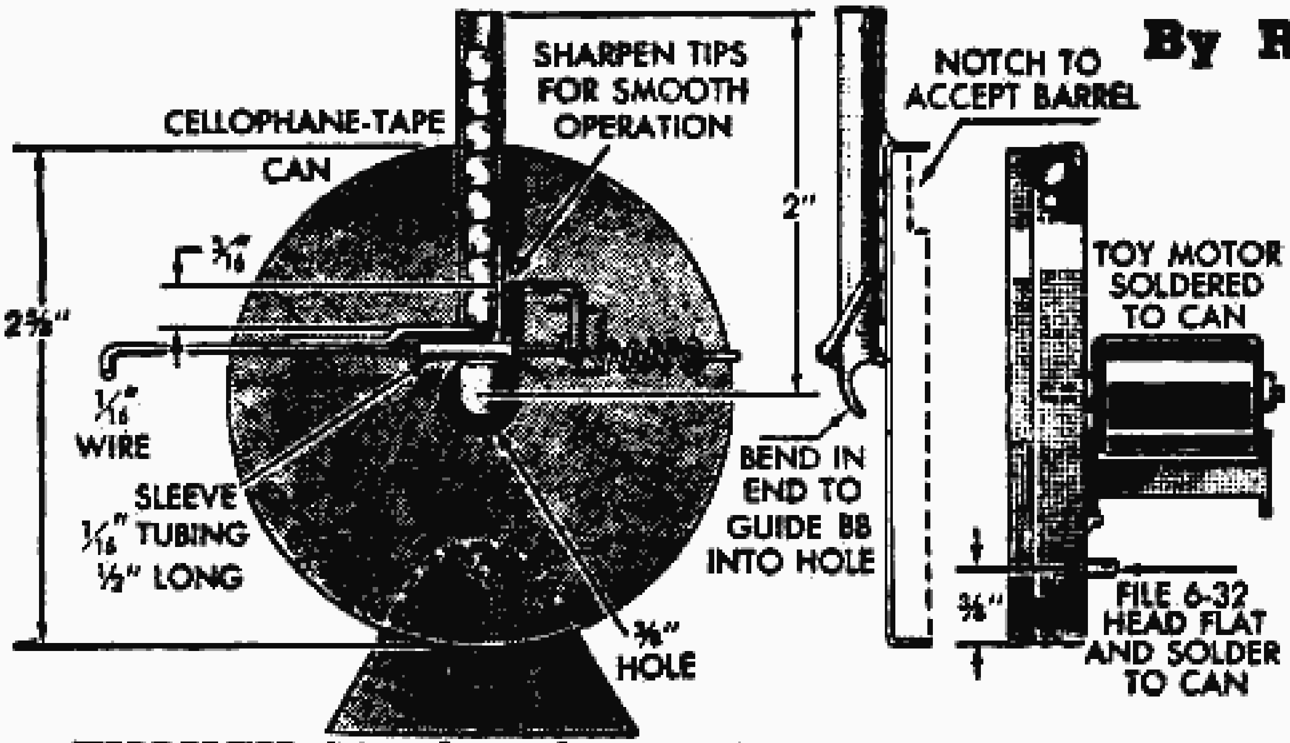
This diagram and short description, sent by a friend, does not show the connection between the two batteries and the motor. Even so, one going so far as to build the model will find the hookup elementary.

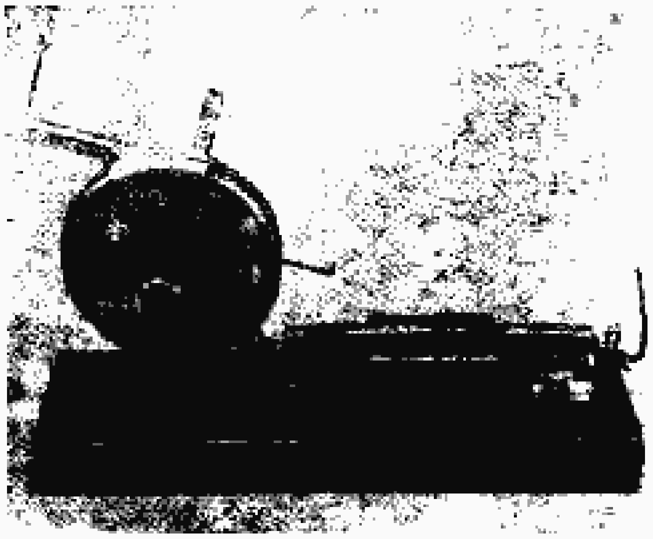
The centrifugal gun, described in The Scientific American, 1861, is obviously a workable concept. The 1861 article, reprinted in THE WEAPONEER under the title "The Baltimore Steam Battery", is a weapon you might consider. In it was described such a gun which shot two-inch balls 150 yards through three one-inch pine planks and landed from three to four hundred yards beyond, powered by human muscle.

Imagine a machinegun, powered by steam, gasoline or electricity, no gunpowder, and silent! I can't see why it was never used, since its 1837 prototype worked and a steam-powered model was patented in 1859. The toy model shown here obviously worked.

It would be interesting to see how the ATF would react to a fully automatic gun using no powder, and thus not being a firearm, and being silent without the use of a silencer.

By Roy L. Clough, Jr.


CELLOPHANE-TAPE CAN
SHARPEN TIPS FOR SMOOTH OPERATION
2"
NOTCH TO ACCEPT BARREL
3/16"
2⅜"
1/16" WIRE
SLEEVE 1/16" TUBING ½" LONG
BEND IN END TO GUIDE BB INTO HOLE
⅜" HOLE
TOY MOTOR SOLDERED TO CAN
⅜"
FILE 6-32 HEAD FLAT AND SOLDER TO CAN



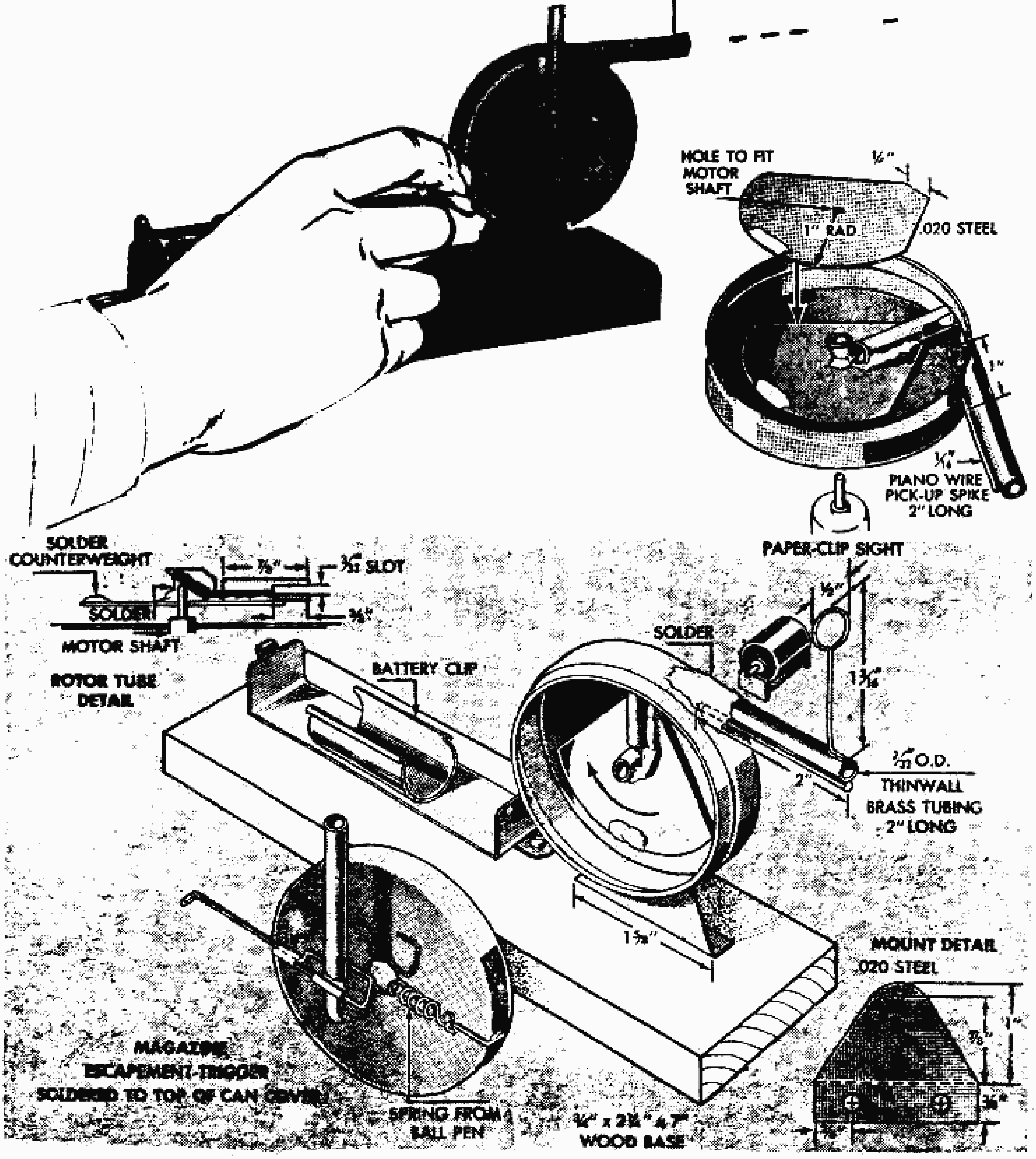
THOUGH this silent shooter throbs with electric power, it's based on just about the oldest ballistic principle on record—the one that helped David clobber Goliath with a sling: pick up a missile, spin it to gather force, then let go. ***Wham!***

Not that this cannon is any giant-killer. We kept it small to be on the safe side. But it's a great demonstration of centrifugal power, and it'll shoot a BB 25 or 30 feet at a muzzle velocity of around 25 feet per second. This may set you thinking of the potential of a centrifugal gun whirled by a gas turbine at, say, 20,000 r.p.m. With an effective swing radius of about 6 in., you'd get a muzzle velocity of over *5000* f.p.s.—better than a high-powered rifle!

The spin mechanism is simple and cheap to build. The toy motor is mounted by soldering its lugs or bushing (or both) into a hole in the bottom of a cellophane-tape can. The rotor that's spun by the motor shaft consists of a base plate to which is soldered a short tube, bent and slotted to allow free passage of the BB shot. This unit must turn without binding; the pick-up spike must pass freely through the end slot. Bevel the opposite end of the tube flush with the top of the can cover.

The end of the magazine tube is undercut and bent so the dropping BB enters cleanly into the whirling pick-up tube. A large paper clip provides wire for the trigger. Pulling back on it releases one shot while blocking the others. This lets the rotor recover its speed between shots.

It spits BB shot with a hum and a click—no flash, no bang. Instead of explosives or compressed gas, there's a spinning motor


HOLE TO FIT MOTOR SHAFT
1/8"
1" RAD.
.020 STEEL
1"
1/16"
PIANO WIRE PICK-UP SPIKE 2" LONG
SOLDER COUNTERWEIGHT
7/8"
3/32 SLOT
SOLDER
3/8"
MOTOR SHAFT
ROTOR TUBE DETAIL
PAPER-CLIP SIGHT
1/2"
SOLDER
BATTERY CLIP
1 3/16"
2"
3/32 O.D.
THINWALL BRASS TUBING 2" LONG
1 5/8"
MOUNT DETAIL
.020 STEEL
1"
5/8"
3/8"
3/8"
MAGAZINE
ESCAPEMENT-TRIGGER
SOLDERED TO TOP OF CAN COVER
SPRING FROM BALL PEN
1/4" x 2 1/4" x 7" WOOD BASE

Gunpowder

This gunpowder is more like the old-fashioned gunpowder used before smokeless powder was invented. It is quite powerful when made right and properly confined but is still not as good as smokeless powder, which is really guncotton.

The formulas here are for what is known as black powder, to distinguish it from smokeless powder.

The simplest black powder is meal powder, mixed dry. This is used mainly for fireworks.

The general formula for black powder is, by weight, 15 parts potassium nitrate, three parts powdered charcoal and two parts sulfur. The ingredients are ground, separately, as fine as possible, or fine enough to go through a 100 mesh screen.

For a better quality powder, add one-half part of dextrine or one part Lepage's Mucilage and enough water to form a thick mush. Stir and mix well and then rub it through a window screen in a thin layer on waxed paper. A lot will stick to the bottom of the screen. Let this dry until it can be scraped off without the particles going back to mush or being so dry as to become powder.

When the particles are firm but slightly damp, sprinkle them with one-half part fine graphite. Then put them in a round bowl with a plastic cover and gently swirl them so they will become round and uniform.

Next, put them on the window screen and shake it gently until all the proper sized pellets have fallen through. Press the larger pellets through the screen into the bowl and swirl them again and keep this up until all the pellets are uniform or until you are no longer amused.

Even better powder can be made by substituting undistilled rubbing (70%) alcohol for plain water.

Gunpowder, both black and smokeless, can be bought at sporting goods stores. It is used for reloading. It has to be signed for but a person who practices at a rifle range and loads his own can prove a legitimate reason for buying tons of it. He can funnel off any amount of it for other purposes.

All grades of gunpowder are suitable for making bombs and grenades. Of course, commercial powder, and especially smokeless, is more powerful than anything you can make at home.

Of the smokeless powders, Bullseye Pistol Powder is the most potent. The strength range is, first, smokeless pistol powders, then rifle powders. Next, commercial black powder and last, the homemade kind.

Fuse

The simplest fuse is made from gunpowder mixture, using the dextrine or glue but omitting the graphite. A length of cotton twine is stirred in the mush, which is wetter than that to be used for gunpowder, and when well coated it is hung up to dry.

If a thicker fuse is wanted, the coated string is folded along its length once or twice, depending on how thick you want it. Then a heavy object is attached to one end and spun, twisting the strands. The other end of the fuse and the heavy object are secured so the strands will remain twisted until dry.

The dried fuse, whether one or more strands, is stiff and brittle. With any bending the powder drops off in spots, making it burn unevenly. If your fuse is going to be handled or will be out in damp weather, you should make some Micky Mouse safety fuse.

Up to three feet of masking tape is unrolled and placed sticky side up on a table. Three-quarter inch wide tape is used for one-strand fuse and one-and-one-quarter inch wide tape is used for the four-strand fuse.

The dry fuse is simply laid along the tape's edge and the tape is rolled over it until it is nice and tight. It is then cut into the desired lengths.

A more sophisticated safety fuse is made by coating the fuse with spray-on plastic from an aerosol can. When this dries the fuse is coated with rubber mold compound, bought at any hobby store. The plastic is used first because the mold compound has a water base and would wet the fuse. The rubber would dry but the fuse would stay damp indefinitely.

Fuses of all kinds are best lit with the material used to ignite highway flares.

Commercial safety fuse is almost impossible to light with a match. Coating its end with flare igniter makes it easy to light and also keeps loose powder from dropping out the ends. This also applies to homemade or other fuses.

Flare igniter is gotten from highway flares you can buy from any auto supply or surplus store for as little as $.15 each. The black igniting core is dug out, crumbled and dissolved with carbon tetrachloride, bought at any auto supply store.

Carbon tetrachloride is commonly used for dissolving grease from auto parts. Just enough is used to dissolve the igniter and it is then evaporated off in a well ventilated area as the fumes are harmful.

The gray powder is then mixed with just enough water to make a thick paste. The fuse ends are then dipped into the paste and dried.

The most difficult to light fuses are easily lit by a match or even with a drop of sulfuric acid.

If you don't want to waste a lot of fun flares you can make your own ignition mixture, which is the same stuff as found in flares.

A lifetime supply of the black part is made with 1½ ounces of black antimony sulfide, 2½ ounces of potassium chlorate and one ounce of dextrine or 1½ ounces of Lepage's Mucilage.

The black antimony sulfide and the potassium chlorate are both wet before being mixed. If they are mixed dry an explosion can result. Then add dextrine or glue and enough water to make a thick paste.

You don't need much of the red striker mixture. One striker can be used to light many fuses.

The red striker mixture is made with 1¼ ounces of red phosphorus, ½ ounce of dextrine or 3/4 ounce of Lepage's Mucilage (from the dime store) and 3/4 ounce of fine sand. Enough water is added to make a paste, slightly thinner than the black paste.

The striker is a tongue depressor, bought at the drug store, or any similar light, thin piece of wood. A couple of inches of the striker is smeared with the red paste and allowed to dry. The red paste should be stirred well before using as the sand will sink to the bottom after a time.

Sulphuric Acid

MAKING SULPHURIC ACID

GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY has directions for making a wide range of needed chemical compounds from easily gotten raw chemicals. Those directions were taken from DICK'S ENCYCLOPEDIA OF PRACTICAL RECEIPTS AND PROCESSES, first published in 1872. DICK'S failed, however, to give a simple method of making sulphuric acid. Its compilers obviously thought sulphuric acid would always be so easy to buy from commercial producers that individuals would never need to make it.

DICK'S method of commercial production (3855) is too complex and the simpler method, credited to Nordhausen (3858) is too sketchy. It is also impractical, although you can easily modify the multi-flask method I found in the AMERICAN MECHANICAL DICTIONARY, 1876, to a one flask setup if you want to try it.

Since the home manufacture of sulphuric acid is so important, I have included it here. The simple chemicals needed are: sulphur, bought at any garden store, calcium chloride, (4247) and iron (ferric) oxide, which is simply iron rust.

The glassware can be bought from any chemical supply company or even from your local pharmacy.

The following instructions will enable you to make sulphuric acid, nitric acid and Turkey-red oil, used in dying. The methods here are for making small quantities but you can modify your setup for making larger amounts.

Essentially, sulphuric acid is a thick, oily, water solution of sulphur trioxide. Concentrated acid is made commercially by the "contact" process in which sulphur dioxide, produced by burning sulphur or roasting iron pyrites, is passed over a heated catalyst, which causes it to combine with oxygen of the air to form sulphur trioxide. Since the finely divided sulphur trioxide cannot be dissolved directly in water, it is added to concentrated sulphuric acid, forming a superconcentrated or "fuming" acid which is easily diluted to the required strength.

You may demonstrate this "contact" process in your kitchen laboratory, with the simple apparatus shown. Your sulphur dioxide producer is a tin-can cover on which you set fire to a mound of sulphur. The gas is collected by an inverted funnel held just high enough for air to come under its rim. Tubing carries the sulphur dioxide to the bottom of a pickle jar filled with lumps of calcium chloride which filter and dry it. For a catalyst, moisten a little asbestos fiber and shake it with a quarter

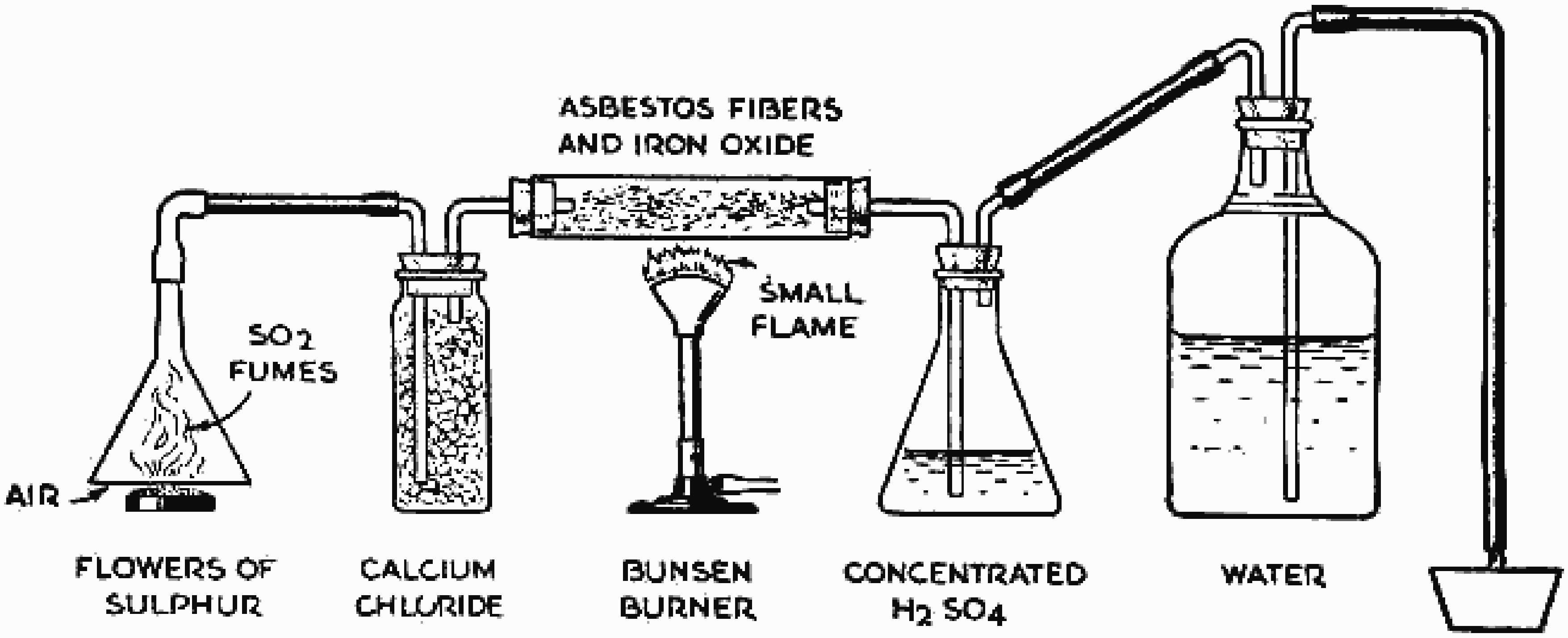
WARNING

Never pour water into concentrated sulphuric acid. They will boil and spatter over the room. This is caused by the acid's great affinity for water. The only safe way is to *pour the acid into the water,* stirring constantly. Likewise, concentrated sulphuric acid will draw water out of the skin, leaving a dangerous burn.

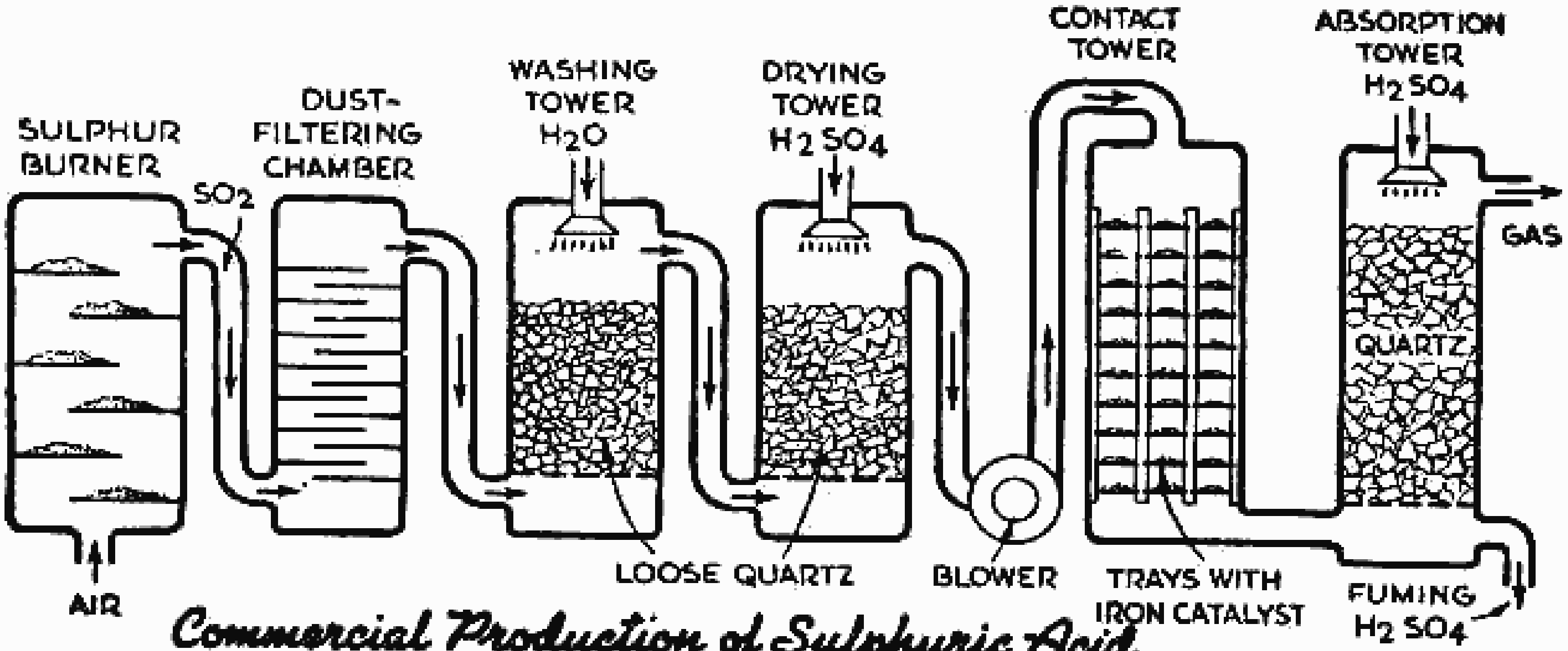
of its bulk of iron oxide. When thoroughly mixed, dry in an oven and pack loosely in the glass tube which is arranged horizontally in your setup. The remaining flask contains concentrated sulphuric acid. The half-gallon jar is a siphon bottle which draws the gas through.

The Bunsen burner must be adjusted for gentle heat or the sulphur trioxide will decompose again. A marked increase in the concentration of the sulphuric acid in the flask occurs in a few minutes. By adding it to water—in diluting, always *pour the acid into the water*—you get a greater quantity of acid of the original strength.

Sulphuric acid is used in making many other acids. As an example, nitric acid—tremendously important in manufacturing explosives and cellulose films—may be made in your home laboratory, but use a glass retort as nitric acid reacts on cork and rubber. Through a paper funnel, drop 25 grams of sodium nitrate into the retort. Carefully pour 20 cc. of concentrated sul-


ASBESTOS FIBERS AND IRON OXIDE
SO_2 FUMES
SMALL FLAME
AIR
FLOWERS OF SULPHUR
CALCIUM CHLORIDE
BUNSEN BURNER
CONCENTRATED H_2SO_4
WATER

Sulphuric acid can be made in your home laboratory with odds and ends like the apparatus shown in diagram above. Commercial manufacture by the "contact" process, illustrated schematically below, is essentially the same


SULPHUR BURNER
SO_2
DUST-FILTERING CHAMBER
WASHING TOWER H_2O
DRYING TOWER H_2SO_4
CONTACT TOWER
ABSORPTION TOWER H_2SO_4
GAS
QUARTZ
AIR
LOOSE QUARTZ
BLOWER
TRAYS WITH IRON CATALYST
FUMING H_2SO_4

Commercial Production of Sulphuric Acid phuric acid on the nitrate. Arrange the retort with its stem extending into a test tube immersed in ice water and its bowl resting on a square of wire gauze with an asbestos center. When the crystals are thoroughly moistened, heat the retort gently, distill at a low temperature until no more vapor condenses, and then allow to cool. The drops of liquid in the test tube will be pure nitric acid. HANDLE WITH CARE!

An important property of concentrated sulphuric acid is its eagerness to absorb water—a property employed to dry gases which are bubbled through and to remove water formed during chemical reactions. This dehydrating action can be demonstrated by dropping sulphuric acid on sugar. The mixture boils, then blackens and swells.

Dilute acid does not absorb water, however, and this may be shown by an amusing "stunt." Write with it on a piece of paper, and the writing will be invisible. Heat the paper, and the lines become visible as the water evaporates and the concentrated acid chars the paper.

Dilute sulphuric acid acts differently from concentrated in several ways, and, strangely enough, is often more active. Drop a little dilute acid on a piece of clean zinc or iron and it "attacks" the metal instantly, forming a sulphate and furiously releasing bubbles of hydrogen. Use cold concentrated acid and little or no action occurs. Heat the metal, and the concentrated acid will oxidize it and then form a sulphate.

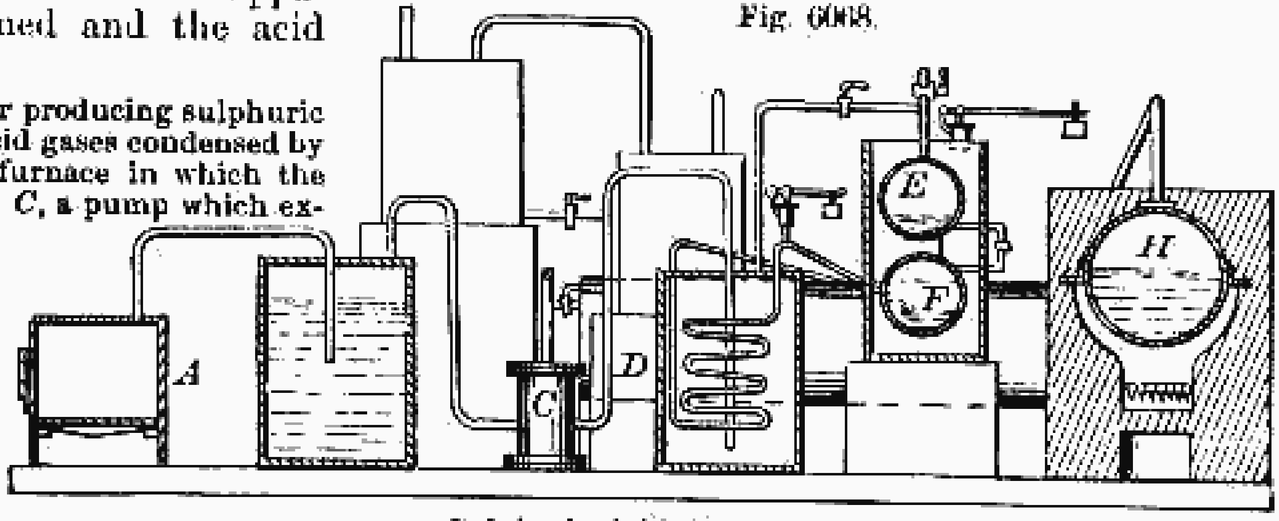
One of the greatest uses of sulphuric acid is in the production of fertilizers. In 1941, nearly a fourth of the total production was applied to this purpose. Phosphate rock, as found in the earth, is practically insoluble and of no use to plant life. Treatment with sulphuric acid changes it into soluble calcium phosphate, a valuable plant food. Two other important uses, in storage batteries and in electroplating, derive from its high electrical conductivity.

Shake a little sulphuric acid with an equal amount of castor oil or olive oil, and the result is a thick dark-reddish material called Turkey-red oil, which is used in the dyeing industry as a "wetting agent" to make dyes penetrate more evenly and easily. Having molecules which are partly attracted to water and partly to oil, it lowers the surface tension of water, spreads more readily.

Sul-phu'ric-ac'id Ap'pa-ra'tus. An apparatus in which sulphur is sublimed and the acid condensed.

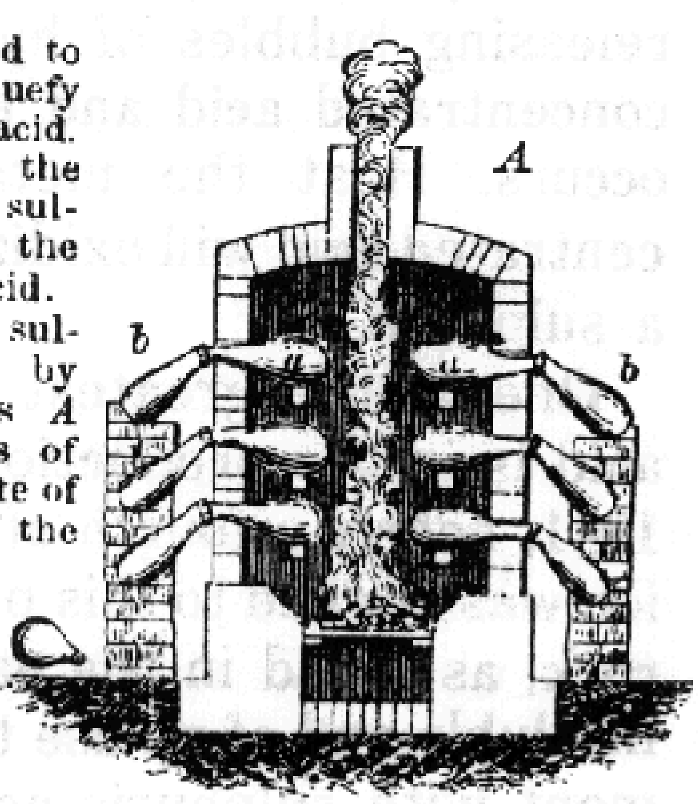
Fig 6068 illustrates Tait's apparatus for producing sulphuric acid by means of sulphurous and nitric-acid gases condensed by pressure into the liquid form. *A* is a furnace in which the sulphur is burned. *B*, the first purifier; *C*, a pump which exhausts the gas from the first purifier, and forces it into the second purifier *D*, whence it is driven into the condenser *E*, where it is condensed into a liquid and drawn off into the cylinder *F*. The communication between *E* and *F* is then cut off, and a valve in the worm-pipe passing through the second purifier *D* is opened, relieving the pressure which maintains the sulphurous acid in liquid form, and permitting it to assume the gaseous condition. It flows through this pipe into a receiver, where the nitric-acid gas, oxygen, and steam from the boiler *H* are admit-

Fig. 6068.



Sulphuric-Acid Apparatus.

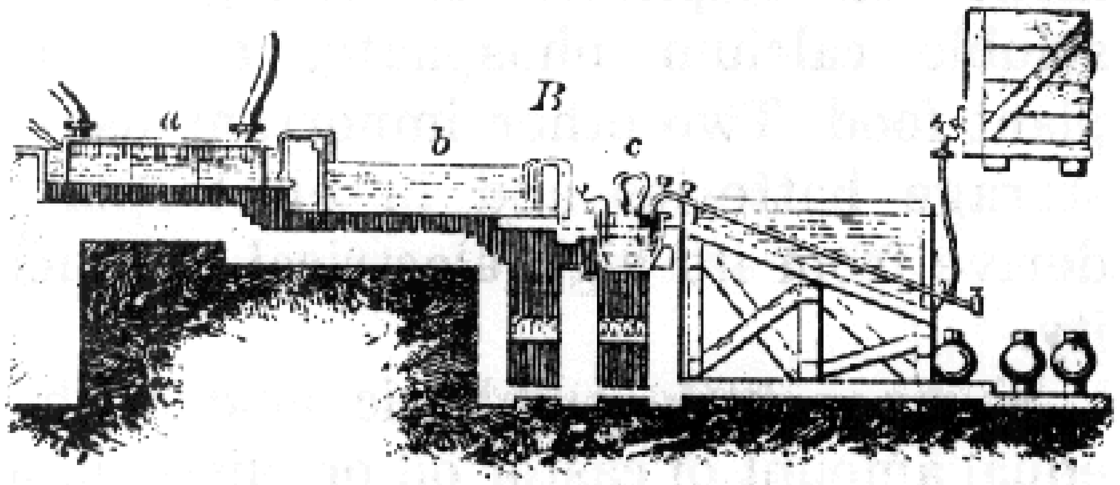
Fig. 6069.



ted, and is then submitted to a pressure sufficient to liquefy both it and the nitric acid. The reactions between the oxygen and the nitric and sulphurous acids result in the production of sulphuric acid.

Fuming or Nordhausen sulphuric acid is prepared by means of the apparatus *A* (Fig. 6069). 2½ pounds of vitriol stone (dried sulphate of iron) are placed in each of the flasks *a a*, etc., made of fire-clay, whose necks pass through the walls of the furnace; on the first application of heat only sulphurous acid and weak hydrated sulphuric acid pass over, which are usually allowed to escape. When white vapors of anhydrous sulphuric acid appear, the necks of the flasks are luted to the receivers *b b*, each of which contains 30 grammes water, and the distillation continued from 24 to 36 hours, when the flasks are again filled with the sulphate: this operation is repeated four times, before the acid is deemed sufficiently strong. Its specific gravity varies from 1.86 to 1.92 This variety is principally used for dissolving indigo; 1 part being mixed with 2 of the common acid for this purpose.

B is the apparatus employed for concentrating the ordinary sulphuric acid of commerce. The weak acid, prepared by the absorption in water of the gas evolved by calcining pyrites, is transferred to the leaden chamber *a*, connected by a siphon with the similar chamber *b*; the latter and the retort *c* are heated directly by furnaces, and the former by a flue therefrom; during the transference from the first to the second chamber the acid acquires a higher degree of concentration, and is then, by means of a second siphon, conveyed from thence into the retort, where water and weak acid are driven off, strong acid, of specific gravity 1.78 to 1.8 remaining in the retort, whence it is withdrawn by a platinum siphon of peculiar construction. The retort is also in many cases made of platinum, but glass is also frequently employed.



Sulphuric-Acid Apparatus.

EXPLOSIVE - (RDX)

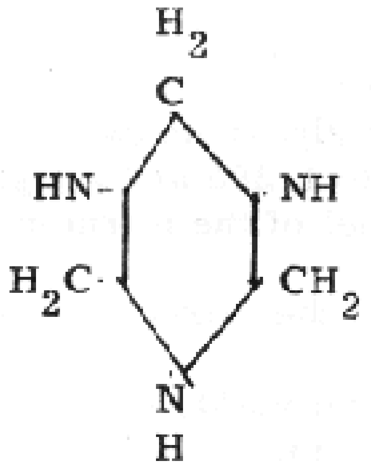
The well known nitro explosives used in practice belong both as regards their chemical constitution and also their properties and effects in general to two different groups, viz. the ethereal salts of nitric acid and the nitro compounds proper. Typical representatives of the first class are nitro glycerine and guncotton, of the second the aromatic nitro compounds such as trinitrotoluene, picric acid and tetranitromethylaniline. The most prominent features of the ethereal salts of nitric acid are on the favourable side the high amount of energy they contain and on the unfavourable side their easy liability to decomposition and their extraordinarily great sensitiveness towards mechanical influences. In contradistinction hereto is the behaviour of the aromatic nitro compounds. Their advantages are in particular their extraordinary chemical stability and their marked non-sensitiveness towards shock, but their disadvantage is their comparatively low energy.

These oppositely contracted properties explain the various attempts which have been made to provide an explosive, which shall combine in itself only the advantages of both classes of explosive, -that is to say a compound, which, in addition to the stability and non-sensitiveness of the aromatic nitro compounds exhibits the degree of energy of the ethereal salts of nitric acid. As a result of these attempts hitherto obtained, certain tetranitrated benzene derivatives with the only recently prepared tetranitraniline are the chief. These compounds are most certainly an advance in this direction, but they have not fulfilled the expectations demanded of them, because, as it was subsequently found, the increase in energy conferred by the fourth nitro group was obtained at the expense of a serious decrease in their stability. Owing to a decided liability of the fourth nitro group, which is situated in the meta position, these highly nitrated substances are so liable to decomposition, that any practical use thereof is not to be thought of.

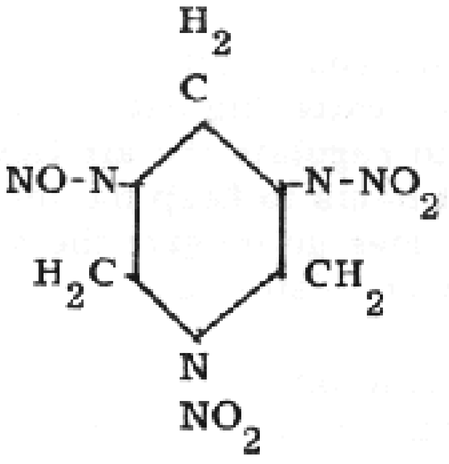
In this way therefore the end aimed at cannot be attained and there are consequently at present no prospects of the realization of this idea.

Now according to the present invention it has been found that hexamethylenetetramine, the well known condensation product obtained from formaldehyde and ammonia, yields, when suitably treated with concentrated nitric acid, an extraordinarily powerful explosive compound, which combines in itself in an absolutely ideal manner the favourable properties of the ethereal salts of nitric acid and the aromatic nitro compounds.

This new explosive substance is neither an ethereal salt of nitric acid nor a pure nitro compound, but is a nitramine with a peculiar ring formation. As chemical investigation has shown, it is derived like hexamethylenetetramine from the hypothetical cyclotrimethylenetriamine



and possesses the following structural formula:



This cyclotrimethylenetrinitramine is formed from all the accessible derivatives of cyclotrimethylenetriamine by the action of concentrated nitric acid. For its production on a large scale, however, only cyclotrimethylenetrimethyltriamine, that is the condensation product obtained from formaldehyde with methylamine could be entertained as a raw material in addition to the already known hexamethylenetetramine, as the other derivatives are difficultly accessible and therefore not economical.

The cyclotrimethylenetrinitramine obtained in this way is a brilliantly white, odourless and tasteless rather coarsely crystalline powder of a neutral reaction. It melts at 200° C. and only detonates at higher temperatures. It is quite insoluble in water, difficultly soluble in hot alcohol more easily so in acetone glacial acetic acid and concentrated nitric acid from which substances it can also be recrystallized.

The cyclotrimethylenetrinitramine is not attacked by either boiling water nor by hot dilute acids and exhibits when subjected to the usual hot storage tests even at unusually high temperatures quite a remarkable stability. It is extraordinarily non-sensitive towards shock, blows and friction and in this respect is about equal to the aromatic trinitro compounds. When ignited it burns slowly without exploding with a bright reddish flame and a fizzing noise like tetranitraniline and leaves no residue.

The most surprising feature of this compound however is its extraordinary explosive and shattering power. In this respect the cyclotrimethylenetrinitramine exceeds all the explosive substances hitherto known, both the enormously energetic nitroglycerine and also the rapidly detonating tetranitraniline. This property it owes, in addition to a composition which permits of fairly complete internal combustion, to its high endothermic character principally. Whereas the formation of the most of the nitro explosives takes place with frequently a considerable loss of energy, the welding together of the cyclotrimethylenetrinitramine from the elements requires the astonishingly high amount of 81.4 calories per molecule. This latent fixed energy is again manifested on explosive decomposition and increases the amount of energy of this explosive to an unusually high amount. Hand in hand with this increase of energy there appears to be also the velocity of detonation which is greater than that of any other known explosive substance. Since there is added as a third factor an extremely large volume of gas due to the large amount of nitrogen and hydrogen contained, this new explosive seems to be of quite enormous effect, which is also clearly shown actually by the surprising results of the lead block and penetration tests.

Another requirement, which is demanded of a good explosive, that of a high density, is possessed by cyclotrimethylenetrinitramine in quite a remarkable degree. The absolute specific gravity is 1.82 and this is a maximum not possessed by any nitro compound hitherto. This fact enables very high loading densities to be obtained which is of great importance for many purposes, e.g., bursting charges for projectiles, detonators and percussion caps.

The following table will show the comparison of all these constants of explosive science with those of other explosives. (See next page)

A point of importance which is not to be underestimated is also the behaviour of cyclotrimethylenetrinitramine in a sanitary direction. In contradistinction to most of the other nitro compounds it is absolutely non-poisonous, has no tinctorial properties, is completely odourless and tasteless and does not cause either in the form of dust or solution any irritant affections of the respiratory organs and the skin. In juries to the work people by the usual discolourations of the skin, injurious action on the sense of taste, eruptions, headaches and easy chronic poisoning which are caused in the preparation and handling of the nitro compounds are therefore precluded and the complicated hygienic precautions hitherto necessary become partially superfluous.

From these remarks it will therefore be clear, that in cyclotrimethylenetrinitramine we have a perfectly new, hitherto unknown explosive, which combines in itself in an ideal way the advantages both of the ethereal salts of nitric acid and also those of the aromatic nitro compounds, combined with remarkable stability and non-sensitiveness while it surpasses all hitherto known and practically usable explosives in energy, shattering power and density and combines with these extraordinary properties in an explosive respect many advantages also as regards sanitary conditions.

Its possibilities of use embrace in respect of the large number of excellent properties which it possesses, all branches of civil and military explosive science. In addition to its use for bursting charges for projectiles, mines, and the like, and as a blasting agent for all mining and mineralogical purposes it is particularly suitable for the production of extraordinarily rapidly acting detonating fuses and in conjunction with initial means of ignition for the filling of percussion caps, detonators and fuses for projectiles. According to the use for which it is required and the effect aimed at the cyclotrimethylenetrinitramine may be used alone, or in conjunction with or mixed with other explosives or components of explosives.

NITROGLYCERIN

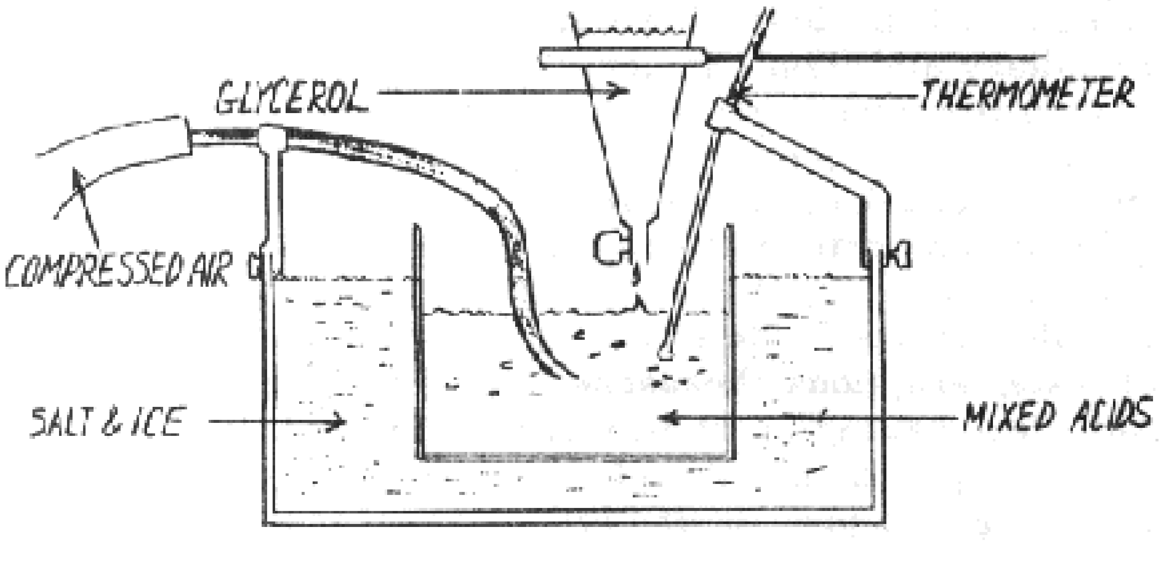
Basically, the production of nitroglycerin involves the gradual adding of glycerol to a mixture of nitric and sulfuric acids followed by separation of the nitroglycerin from the waste products. The following directions will serve for the laboratory preparation of nitroglycerin in small amounts.

PREPARATION OF THE MIXED ACID:

(1) Measure out 200 ml. of fuming, or 90% Nitric acid having a specific gravity of 1.5 at room temperature.

(2) Measure out 300 ml. of concentrated, or 98% sulfuric acids, having a specific gravity of 1.84 at room temperature.

(3) Slowly pour the Sulfuric acid into the Nitric acid, and start letting it cool off in the salt-ice bath.



ACTUAL NITRATION:

(1) Measure out 1 unit (oz., mo., gram, etc.) of chemical pure glycerol, or glycerine (water free) having a specific gravity of 1.262 to 1.265 at 15 degrees centigrade, into the dropping funnel of the nitrator.

(2) Put 6 like units of the mixed acid into the nitrator tank.

(3) One unit of glycerol yields about 2-1/3 units of nitro so you can judge the amount of glycerol to use by the amount of nitro you wish to make.

(4) The nitrator can be made of glass, cast iron, lead, or steel.

(5) Start the air flow and regulate it so that the acids are well stirred but not spattering out of the nitrator. Use a screw type clamp to regulate the air flow, and watch the flow carefully as it helps to keep the temperature down. If the temperature does go up give the nitrator as much air as you possibly and safely can.

(6) Start the glycerine into the nitrator in a fine, slow stream or even by the drop, depending on the temperature rise, and the speed and violence of the reaction. With plenty of time available the drop method is advisable.

(7) The ice bath is salt and crushed ice and small amount of water.

(8) Use a total immersion centigrade thermometer in the acids in the nitrator. The nitrating temperature is kept below 22 degrees centigrade. If it runs higher, cool it off. The temperature can go up 30 degrees C. without too much danger. The nitro being produced will start to decompose at 50 degrees C. and give off the red gas of nitrogen dioxide, which is poisonous. Don't let this happen. If there is a sudden rise in the temperature or the red gas is noticed, DUMP THE WHOLE WORKS INTO THE COLD WATER!

(9) Keep the reaction cool, and the air stirring going until the temperature of the reaction comes down to 15 degrees C and remains there or a little cooler.

SEPARATION AND WASHING:

(1) Pour the cool solution from the nitrator into plenty of room temperature water. Now run this water-nitro-acid solution in the separator.

(2) Separate the "liquors" or waste acids from the nitro. The nitro will be heavy oil on the bottom.

(3) Keep the "liquors" separate for further separation with chloroform, if one wants to do this. This is only done AFTER neutralizing the acids with sodium carbonate solution. Check the acidity with blue litmus paper. When it is neutral, the litmus will stay blue and show NO red.

(4) Add plenty of 38 to 43 degree C water to the nitro and mix up with the air stirring. Then separate.

(5) Repeat the washing completely as above.

(6) Wash with a warm, 4% solution of sodium carbonate.

(7) Wash with water 3 more times as in step #4.

(8) Give it a final wash of concentrated salt solution, let it set for one day before separating.

(9) Separate and check the nitro for acidity. The nitro must be neutral. If it is not, keep washing it. It MUST be neutral due to safety and keeping qualities.

DRYING:

Dry the nitro over sulfuric acid in a dessicator. The nitro should have a specific gravity of 1.6 at 15 degrees C. It may take several days for the nitro to dry out.

CHLOROFORM SEPARATION:

Add an equal quantity of C. P. Chloroform to the NEUTRAL "liquors." Mix, then let separate and run through the separator. Let the chloroform-nitro set in the open for 1 day so the chloroform can evaporate off as much as possible. Now this nitro can be mixed with the other nitro just before put into the dessicator to dry.

CAUTIONS

(1) DON'T TOUCH ANY 2 GLASSES TOGETHER WHEN POURING AS THE NITRO MAY RUN DOWN THE OUTSIDE OF THE GLASS THEREBY CREATING DANGER.

(2) THE ENTIRE OPERATION SHOULD BE DONE IN THE OUTSIDE OR A WELL VENTILATED PLACE OR UNDER A HOOD OR DUCT.

(3) NITRO IS POISONOUS AND THE FUMES CAUSE SEVERE HEADACHES.

NOTES

(1) THE WARMER THE NITRO IS THE MORE SENSITIVE IT IS TO DETONATION.

(2) FROZEN NITRO CAN'T BE DETONATED, THEREFORE, IT IS SAFE.

(3) THE PROCESS TAKES ABOUT 2-1/2 HOURS EXCLUSIVE OF THE SPECIFIC PROCESSES REQUIRING SEVERAL DAYS.

(4) NITRO IN ITS LIQUID FORM HAS 30 to 60 TIMES THE EXPLOSIVE POWER OF NITRO WHEN IT HAS BEEN ABSORBED IN A DYNAMITE FORM.

THE PROPERTIES AND PREPARATION OF PROPYLEEN GLYCOL DINITRATE (PGDN)

Properties: Nitroglycerine (NG) is the most common liquid high explosive known today. However, there are many other similar liquid nitric esters which have the same explosive properties as NG. Many of these have somewhat inferior blasting power to that of NG (a few are superior) but are more stable towards mechanical shock than NG itself. PGDN is just one such compound, being at least ten times more stable toward s mechanical shock than NG. Under the falling weight test, NG detonates at a height of from two to four centimeters using a two kilogram weight. PGDN fails to detonate under the same weight dropped from a heighth of 100 centimeters. It fails to detonate under a 10 kilogram weight from a height of 20 centimeters. This difference becomes valuable in manufacturing and transportation.

Another property of PGDN which recommends it for serious consideration by any organization is its stability toward storage over long periods of time without suffering any decomposition. Further, PGDN does not freeze as readily as NG, thereby eliminating the hazards of partially frozen NG which is most dangerous to handle. PGDN freezes at minus 20 degrees centigrade, or minus four degrees F. This means that stocks of PGDN can be buried in underground caches without serious danger of freezing, provided they are placed below the frost-line. At the other end of the temperature scale, PGDN shows extreme stability. It shows no decomposition after 25 days at 75 degrees Centigrade. Unlike NG, it does not cause the severe headaches from breathing its vapor. Like NG, it can gelatinize guncotton thereby suggesting its use for the manufacture of cordite and smokeless powder-like substances.

As an explosive, PGDN shows about 90% of the expansion of NG in the Trauzl lead block test. By calculation, its energy content is 77% of that of NG. It is a highly brisant explosive however, and has a detonation rate of over 7,000 meters per second. Despite its high mechanical insensitivity to shock, PGDN is easily initiated by a detonation wave. It can be set off with a number 6 blasting cap.

Propylene Glycol is somewhat cheaper than Glycerine at the present time by about 20¢ a pound in lots of 40 lbs. PG can be purchased from any chemical supply house for about 60¢ to 75¢ per lb. depending on the quantity bought. Furthermore, the nitration of PG requires less of the mixed Nitric-Sulfuric acids. These savings of course are offset by the lower explosive power of PGDN, and may well balance out when all economic computations have been made. Nevertheless, the greater stability of PGDN toward mechanical shock and the lower freezing point far outweigh any other considerations. For this reason, all those who have been manufacturing NG, or who have been considering doing so, should give serious thought to the manufacture of PGDN instead. The process is basically the same, uses the same type of mixed acids, the same procedure for separation and purification and can be run in the same equipment used for NG.

The following procedure was carried out by the writer of this report for the preparation of PGDN during a recent experiment. Although the preparation was conducted on a very small scale, there is absolutely no reason why larger batches cannot be made, provided they are kept within realistic bounds. Batches ten times the size of the one described on the following pages would be reasonable, and would produce approximately 180 grams of PGDN (i. e. 6-1/2 ozs. b/w).

Preparation of Propylene Glycol Dinitrate: 30 grams of 96% Sulfuric Acid was slowly poured with stirring into 20 grams of 90% Nitric Acid. A small amount of heat was produced, but it is not excessive, and no external cooling is required. The 50 grams of mixed acid thusly produced has a composition of approximately 36% Nitric Acid, 57% Sulfuric Acid, and 7% water. It has a specific gravity of 1.71 at 25 degrees C., and occupies a volume of 30 milliliters.

The entire 50 grams of mixed acid was placed in a 100 ml glass beaker which in turn was placed in a bath of ice and water. The acid was stirred by hand, using a thermometer. When the temperature of the mixed acid had sunk to 10% C., 10 grams of Propylene Glycol (9.6 ml) was introduced dropwise with good stirring. The rate of addition of the PG was so regulated to keep the temperature of the mixture between 10 and 15 degrees C. The addition of the PG takes from 20 to 30 minutes, depending on the efficiency of the cooling bath, and the rate of stirring. No red fumes were observed at any time during the addition. The PG should be dropped directly into the acids and not be allowed to splash on the side walls of the beaker or on the stirring rod. Droplets that do so, can start to oxidize and generate heat creating a hazard. PG is more sensitive to oxidation than Glycerine itself, and so a lower nitration temperature is necessary. Nitrations at 20 degrees C. begin to show some oxidation, and at 30 deg. C. the reaction begins to go out of control! IMPORTANT: A large vat of ice water should always be kept near at hand when doing any nitrations. If the temperature begins to climb rapidly and passes the upper limit given for the specific nitration, the entire batch should be dumped IMMEDIATELY into the vat of ice water. The vat should contain at least five times the volume of water and ice as there is liquid in the nitrator. Sudden rises in temperature accompanied by red fumes or brown smoke is an indication that oxidation is taking place, and that the batch is about to go out of control. After the PG has all been added, stirring is continued for another five to ten min. It is then ready for separation.

The mixture is poured into a separatory funnel and allowed to stand for a few minutes. A sharp line of division will appear when the mixture has separated. The lower acid layer of spent acids is carefully withdrawn and set aside for further purification before being discarded. The upper layer of PGDN is left in the funnel and an equal volume of cold water added to it. The funnel is closed, and gently shaken for about a minute. On standing, the mixture divides into two layers as before, but this time the product (PGDN) is the lower layer. It is drawn of into a clean beaker, and the water wash layer, which remains in the funnel, is poured out of the top of the funnel into another vessel. This washing process is repeated two or three more times, each portion of used wash water being added to the previous one. The product is then given a wash with dilute Sodium Carbonate solution until the solution remains alkaline to Litmus paper, the spent Carbonate wash(es) being added to the used water washes. Finally, the PGDN is washed with water again until it is no longer alkaline. When drawn off from the final wash, the PGDN will be somewhat milky in appearance due to occluded water. On standing in a warm room for several hours, this water will evaporate, leaving a colorless oil having a pleasant ethereal odor. 18 grams of product were obtained in the above run.

Before pouring away, the spent acids should be extracted with chloroform to remove traces of PGDN. The same portion of Chloroform can then be used to extract any traces of PGDN in the water and Carbonate washes. After the Chloroform evaporates a further amount of PGDN will be obtained. The chloroform solution should be washed until it is neutral to litmus before evaporation, however. The spent acid, after extraction with the Chloroform, should be poured into a large volume of water before being discarded. All glassware which has come into contact with PGDN must be rinsed with Acetone before soap and water cleaning. These Acetone rinses should be poured over sawdust and ignited at a safe distance from the point of operation. Rinse the nitration beaker with water first before rinsing with Acetone. Nitric Acid ignites Acetone!

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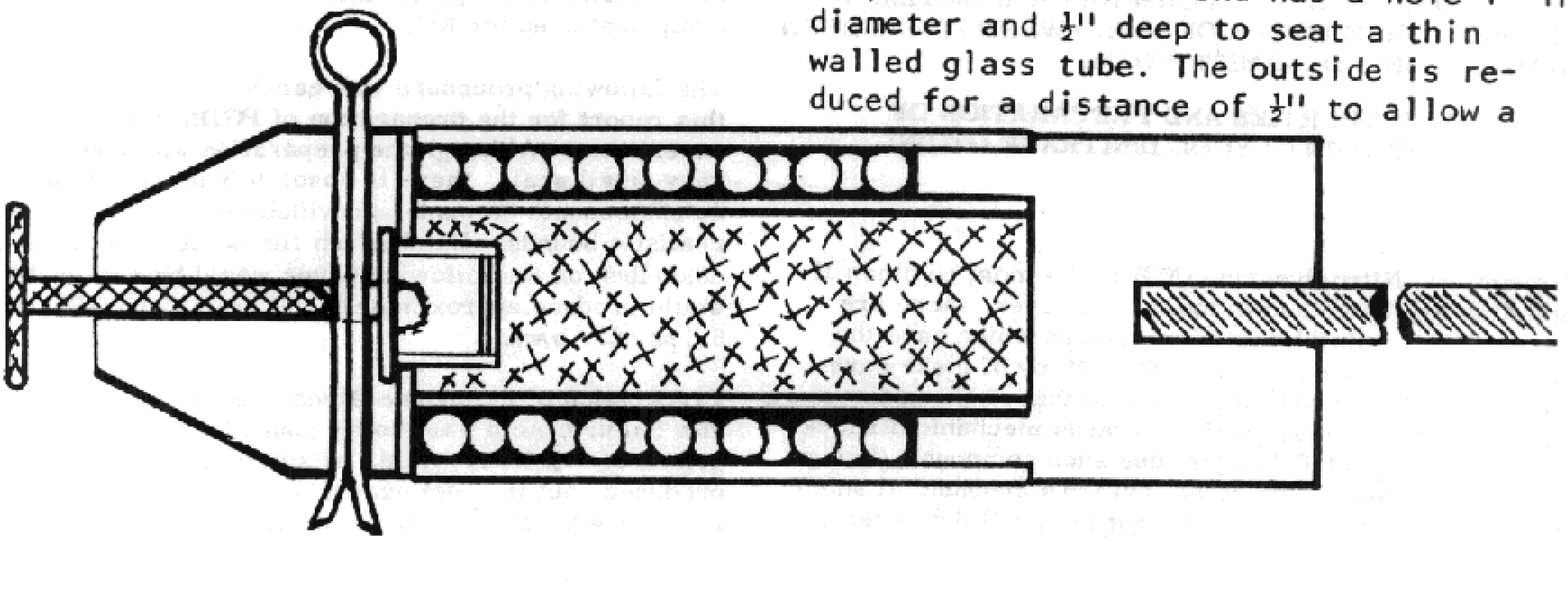
arrow launched grenade

By Raymond J. Larner

This grenade can be used with; a conventional long bow, a compound bow, or a crossbow, which would be my first choice.

The nose and tail caps are cast using either plaster of paris or clear casting plastic.

The tail cap has a hole drilled in it to accept an arrow shaft or a cross bow bolt. The shaft or bolt should be glued in place. The other end has a hole 1" in diameter and ½" deep to seat a thin walled glass tube. The outside is reduced for a distance of ½" to allow a



piece of thin walled metal or plastic tubing to be slipped over it.

The nose cap is cast with two holes through it, (or you can cast it solid and then drill the necessary holes) to take a firing pin and a cotter pin safety. It also has a recess in the bottom to sit over the base of a .410 shotgun shell base.

The initiator is the brass base from a .410 shotgun shell. Carefully cut the shell apart just above the brass base, after first having emptied out the shot, powder and wadding. Once you have the brass base cut down, refill most of it with the powder you removed before cutting it. Use tissue paper or a thin cardboard wad to hold the powder in the brass base.

A steel washer with an outside diameter of 1½" is used to support the shotgun shell brass base. Drill out the center of the washer to accept the brass base. The rim of the brass base should be supported by the steel washer.

The outside casing for the grenade is a piece of thin walled metal or plastic tubing.

The center tube is a piece of thin walled glass tubing that has an outside diameter of 1".

To assemble the grenade:

1. Insert the shotgun shell base into the steel washer.
2. Epoxy the washer to the bottom of the nose cap.
3. Epoxy the glass tube to the steel washer.
4. Epoxy the outer casing to the steel washer.
5. Fill the space between the glass tube and the outer casing with B.B.'s, small nuts and bolts or nails.
6. Fill the glass tube with black powder, rifle powder or one of the propellant powders listed in the Improvised Munitions Handbook in PMJB Vol. 2.
7. Epoxy the base cap to the glass tube and outer casing.
8. Install a cotter pin with non-hardening Permatex and slip it in place until it is sitting on the safety pin.

10. Epoxy the complete grenade to the end of an arrow or bolt.

DANGER NOTE: Make sure the hole for the firing pin is a snug fit. If it is too large, the Permatex may not hold the firing pin in place when you launch it, possibly causing the grenade to explode in your face when you fire it.

The firing pin is a piece of steel rod 1/8" in diameter with a 3/4" OD washer epoxyed or soldered to the end. Make sure the firing pin extends far enough past the end of the nose cap so that it will hit the shotgun shell primer when you hit your target.

Remember that this grenade has to hit something fairly solid to be set off. If shot into sand or mud, it may or may not explode. It would probably be set off if it hit a human or animal, but only if there was plenty of force pushing it.

Make sure that your arrow is long enough for you to come to full draw without having the grenade hit the bow.

Improvised Hand Grenades

by

Dan Moore

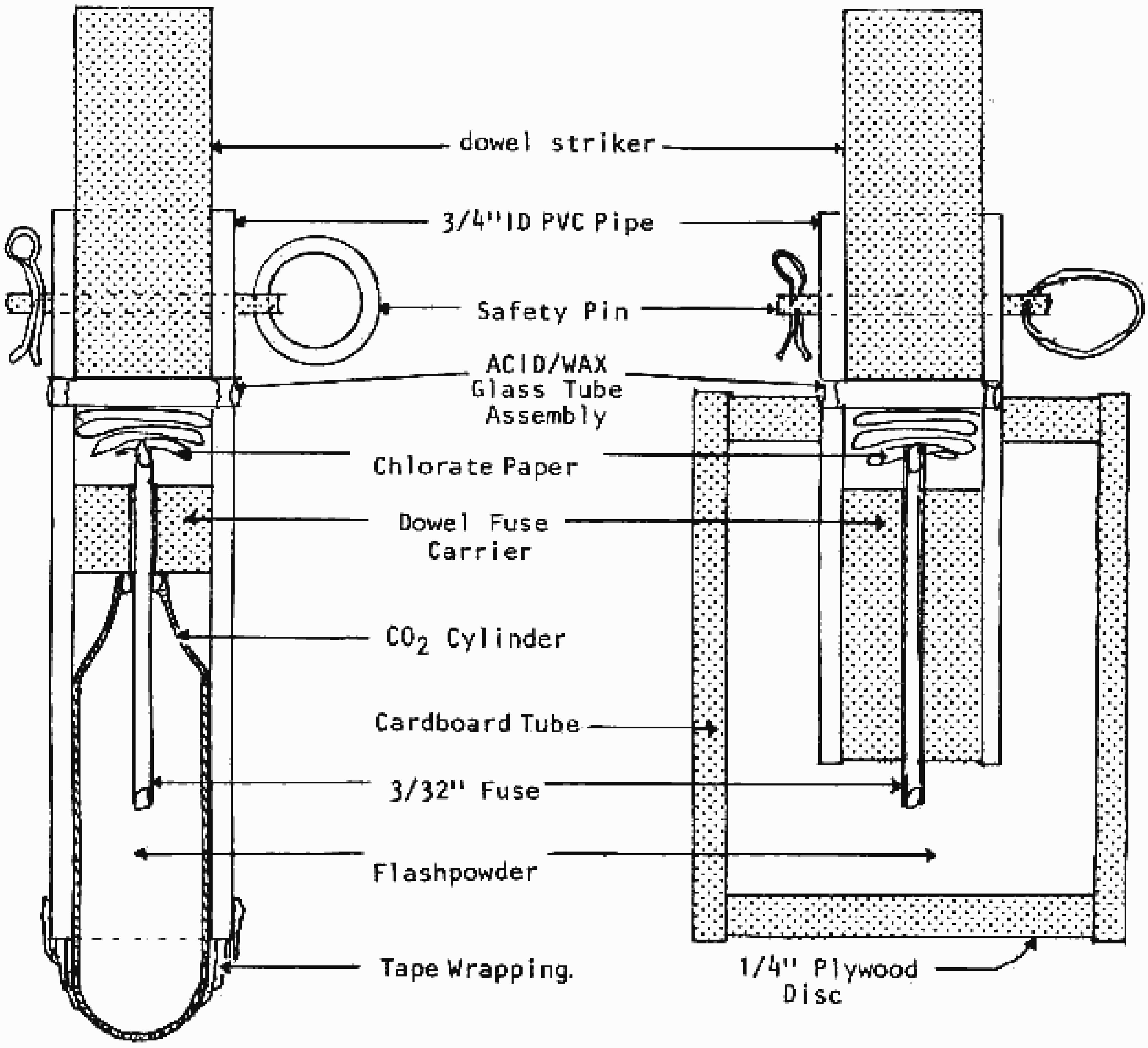
A ready supply of improvised hand grenades can be made in the home workshop at a cost of about 75¢ apiece. These grenades are easy to make and are just as effective as regular grenades. There are two kinds, offensive and defensive, in which both use the same fuse assembly. Additionally, these grenades use readily available materials and can be put together in 15 minutes.

The heart of these grenades is the fuse assembly, therefore I will describe its production first. The materials needed for the fuse assembly are:

1. 3/4" PVC pipe in 4" lengths
2. 3/4" wooden dowel in 2" lengths
3. 5 mm glass tubing
4. 1/8" wooden dowel in 1½" lengths,
5. Paraffin wax
6. Concentrated sulfuric acid
7. 50% sodium chlorate and 50% sugar mixture made pasty with water then blotted on paper towels and dried.

A. Construction of fuse assembly

Start construction of the 'fuse' by drilling a 3/16" hole 1" from an end of the PVC pipe. This hole will hold an acid vial. Next insert a length of 5 mm glass tubing into this hole and place the 3/4" wooden dowel into the PVC pipe so it is touching the glass tubing. Drill a 1/8" hole 1/2" from the dowel end of the pipe. This 1/8" hole is where the safety pin is inserted (see diagram). The safety pin is the 1½" length of 1/8" dowel (a hole can be drilled in an end of the dowel and wire inserted to aid in pin removal). With the 1/8" hole drilled insert the safety pin. This will hold the 3/4" dowel in place (see diagram). The length of glass tubing can be removed. The installation of the chemical ignitor remains.


dowel striker
3/4"ID PVC Pipe
Safety Pin
ACID/WAX Glass Tube Assembly
Chlorate Paper
Dowel Fuse Carrier
CO_2 Cylinder
Cardboard Tube
3/32" Fuse
Flashpowder
Tape Wrapping.
1/4" Plywood Disc

Construction of the chemical ignitor is started by making the acid filled vial. Make this vial by cutting a length of 5 mm glass tubing the same length as the O.D. of the PVC pipe. Next seal one end of the tube with 1/8" of paraffin by dipping it in melted wax. Now fill the tube with sulfuric acid using a glass eyedropper, etc., leaving a 1/8" air space. Fill this space with wax. The vial can now be inserted into the PVC pipe and taped in place. Finish the 'fuse' by inserting a 2" x 2" square of chlorate paper next to the acid vial (see diagram). The fuse assembly is finished.

B. Construction of offensive (concussion) grenade

The materials needed for the offensive grenade are:

1. 2" heavy-walled cardboard tube in 3" lengths
2. two plywood plugs for the above
3. epoxy or glue

4. Flashpowder
5. 3/4" dowel in 1½" lengths
6. 2" length of safety 'fuse'
7. the 'fuse' assembly

Start construction of the grenade by drilling a 3/32" hole through the center of the 3/4" dowel. Then epoxy the fuse into this hole leaving ¼"exposed on either end. Now place a small amount of chlorate paper on one fuse end to insure it ignites (see diagram). Next cut 1" off the open end of the 'fuse' assembly and epoxy the dowel (chlorate paper end first) into it. The chlorate paper on the dowel fuse should contact the chlorate paper in the fuse assembly (see diagram). Continue by cutting a hole the same diameter as the 'fuse' in the center of one of the plywood plugs. Epoxy the fuse assembly into this hole leaving 1" of the dowel end protruding out. Now epoxy this plug into the cardboard tube with the dowel end of the 'fuse' out. Fill the cardboard tube with flashpowder and epoxy the solid plug onto the other end of the tube (see diagram). The grenade is finished.

C. Construction of defensive (fragmentation) grenade

The materials needed for the defensive grenade are:

1. empty CO$_2$ cartridge
2. 3/4" wooden dowel in ½" lengths
3. epoxy or glue
4. safety fuse in 2" lengths
5. flashpowder
6. fuse assembly

Start construction by drilling a 3/32" hole through the 3/4" dowel. Insert the safety fuse through the dowel allowing ¼" on one end and 1¼" on the other. Epoxy the fuse in place. Now fill the CO$_2$ cartridge with flashpowder and insert the 1¼" fuse end into it. Use tape, etc. to secure the fuse. Wrap a small amount of chlorate paper around the short fuse end (see diagram). Place the dowel and CO$_2$ cartridge (chlorate paper end first) into the fuse assembly as before. Be sure to epoxy the dowel into place. Finsih by taping the CO$_2$ cartridge into the fuse assembly (see diagram). The grenade is finsihed.

D. Firing procedure and miscellaneous

The firing procedure for these grenades is as follows. First, grasp the grenade in your hand with the dowel end up. Second, pull the safety pin out. This arms the grenade. Third, strike the dowel end sharply against the palm of your hand, etc. There should be a 'hissing' sound and a small amount of smoke should come from the dowel end. This indicates that the chemical igniter has functioned. Finally hurl the grenade at your target immediately and take cover. The grenade should explode in five (5) seconds.

You now know all you need to make and use my grenades, however, there are a few additional items. I will list these for convenience.

1. Use the offensive grenade to daze and stun the enemy and use the defensive grenade to inflict casualties.
2. 2" PVC pipe can be used as a fragmentation sleeve for the offensive grenade.
3. Grooves, etc. can be filed into the CO$_2$ cartridge or fragmentation sleeve for better fragmentation.
4. Wax placed around the striker makes an effective air and water seal, while a coat of varnish on the grenade will make it waterproof.
5. Offensive grenades can be used for smoke or incendiary purposes by replacing the flashpowder with the appropriate filler.
6. Both grenades make effective landmines when buried exposing only the dowel. Sheet wood can be placed on top of the dowel for increased surface area.
7. Survivalists, etc. wishing to store these grenades should remove the acid vials and store them separately.
8. Chemicals and equipment for my grenades can be purchased from Merrel Scientific; address: Educational Modules Inc., 1665 Buffalo Rd., Rochester, NY 14624. Catalog $1. Merrel has a good line of chemicals and labware with fast delivery. High melting point wax, glass tubing and glass tubing cutters can also be purchased from Merrel.
9. High melting point wax or acid proof epoxy can be used to more effectively seal acid vials. Use this for grenades to be stored.
10. Check PMA Vol.1 #1 for additional grenade information.

Precautions:

11. Make and use several test samples before increasing charge size.

12. Test safety fuse in fuse assembly to make sure it will not jet after being epoxied in place. If it does, try another brand or epoxy the fuse at the dowel ends only.

13. Wait at least two minutes when approaching dud grenades.

Provided these items are considered and the instructions followed anyone should be able to safely make and use these grenades.

FLASHPOWDER

Potassium Chlorate is a highly unstable and dangerous compound when used in a pyrotechnical mixture which also contains sulfur. Combined, these two compounds are sensitive to both heat and friction as well as sparks, and are made more so by moisture absorbed from the humidity in the air. Furthermore, they deteriorate on storage slowly producing sulfuric acid which makes the mixture even more unstable.

Some years back I had the unfortunate personal experience of having just such a mixture spontaneously ignite while I was mixing it on a hot humid day. Had the amount of materials been larger or had I been a bit less lucky, I would have been permanently blinded. Even so, I suffered painful burns to my eyes, face and hands.

Sader, but wiser, I looked for a mixture of equal power, but with better storage qualities and one less hazardous to prepare.

The answer I found involved the use of potassium perchlorate. Although this chemical contains more oxygen than the clorate, it is more stable in both storage and preparation. In addition, I found the sulfur could be eliminated entirely, making the preparation that much simpler.

The ingredients are, by weight, 7 parts potassium perchlorate and 5 parts aluminum powder. Both should be as fine as possible. After weighing they are thoroughly mixed and stored in a sealed container until needed.

This mixture is extremely powerful and very, very fast burning. Well made, with very fine ingredients, it burns about 3-4 times faster than commercially made black powder. It is excellent for use in aerial bombs, large or small firecrackers or any purpose where a quick violent explosion is needed. It is too rapid burning for use in any firearm, and is not suited to such use.

I have kept such a mixture several years with no deterioration, however reasonable storage precautions should be observed. All such mixture type powders, including commercially prepared black powder, should be protected from dampness. All will deteriorate if exposed to large amounts of humid air, but if you use common sense, they will keep indefinitely.

There are also several other mixtures that I have experimented with and found satisfactory. While I do not think any of them are quite as good as that already given, they are noteworthy because they involve the use of other ingredients of the first formula.

Alternative No.1

Bariam Nitrate	4 Parts
Sulfur	1 Part
Aluminum Powder	2 Parts

Alternative No.2

Potassium Perchlorate	12 Parts
Sulfur	8 Parts
Fine Sawdust	1 Part

Alternative No.1 is probably better than No.2 which does not seem to keep as well as the others. However, number 2 makes a very violent explosion. Furthermore it is the only really good formula I have ever seen for flash powder which does not require aluminum powder.

These mixtures, particularly the perchlorate-aluminum powder one, will burn and if confined, explode almost no matter how badly they are mismeasured or poorly prepared. Like most things though, the end result is reflective of the care put into production. The most important thing is to have the ingredients as fine as possible before mixing them together. There is not much you can do about the aluminum except to get the finest powder possible. The potassium perchlorate can be gently ground in a mortar and pestle or by other suitable means if necessary. The goal is to have the texture as near to that of flour as possible. If you have the consistency of table salt, it will work, but not as good.

The second thing is that the ingredients be thoroughly and intimately mixed. If you achieve the desired degree of fineness in the ingredients, the mixing is not very hard, but it must be thorough. Mixing is most easily accomplished with a flat wood stick on several layers of newspaper. Sifting through a small screen, as fine a screen as may be obtained, several times is very useful. It should be done after a preliminary mixing and not only mixes the ingredients but sorts out any large pieces which can then be broken up. Avoid the use of metal and ceramic utensils because of spark and contamination hazards.

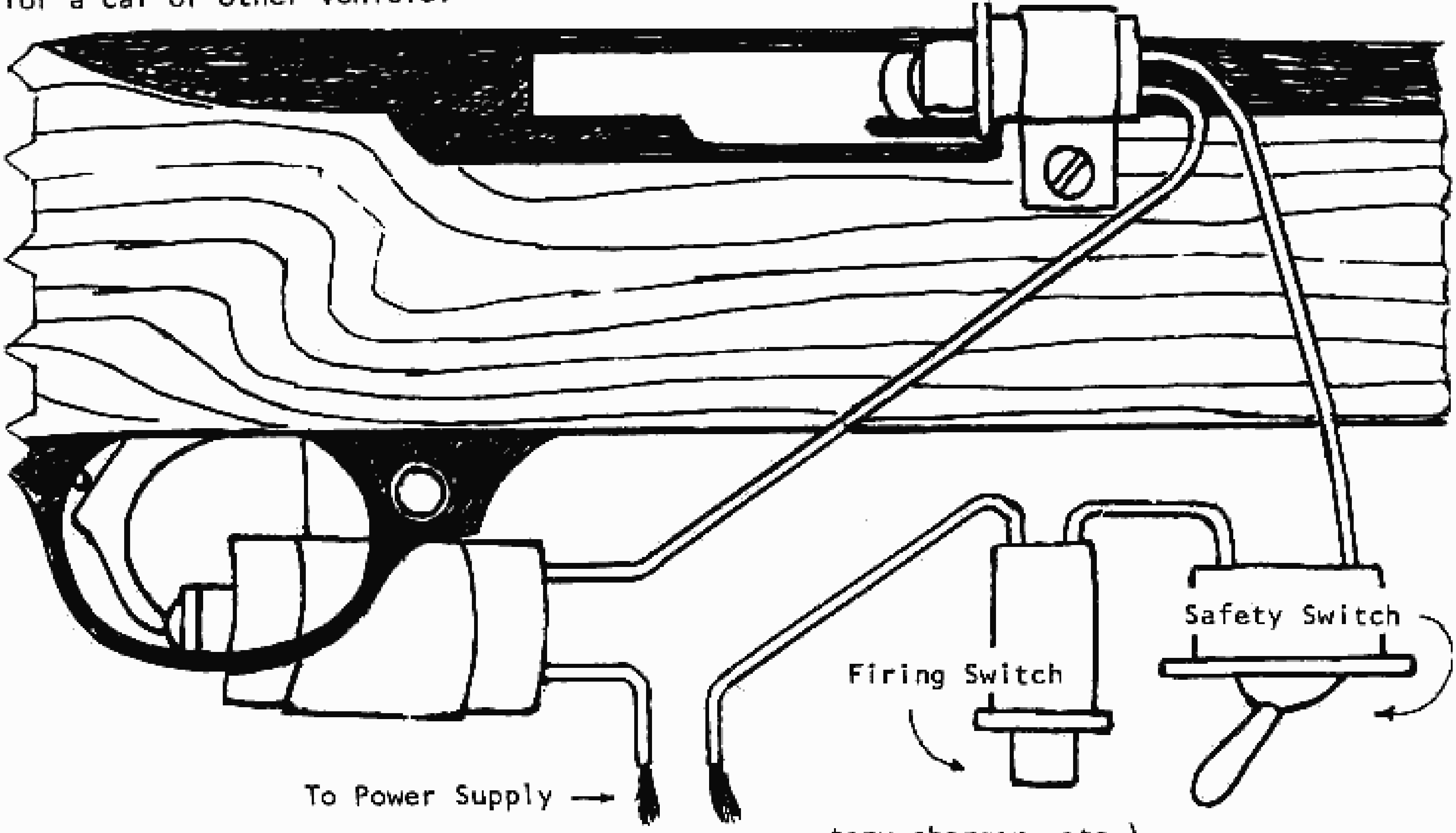
With a little practice, it is easy to judge the quality of such powder by placing a small quantity on a fire resistant surface in an open area and lighting it with a short piece of fuse. Good quality powder will burn almost instantly with an intensly bright flash, and a puff of white smoke.

If made with reasonable care, any of these powders are equal to that usually found in commercially manufactured firecrackers such as M-80's.

ELECTRIC RIFLE

THE KENTUCKY RIFLEMAN

By following the instructions below you can modify any semi-automatic rifle or shotgun to fire fully automatic and by remote control as a bonus! It's great for a car or other vehicle.



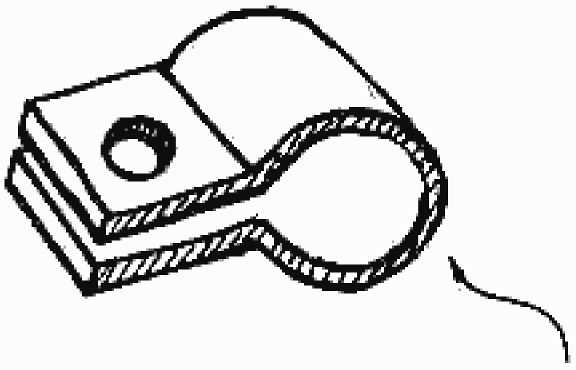
You will need the following parts:

- One 12 volt solenoid. (I used the carburetor solenoid from a Ford van)
- One toggle switch for 12 volts. (Auto supply store or junkyard)
- Two push button switches /normally off. (Auto supply)
- Steel strapping or other light metal pieces for mounting. (Hardware store)
- Misc. wire / does not have to be very heavy.
- One semi-auto weapon. (I used a Ruger 10-22, but others will work)
- A 12 volt power supply. (battery, battery charger, etc.)

Please refer to the drawings when building your system.

1. Start by making mounts for the push

button switches and the solenoid from the steel strapping. The exact design will depend on the switches and solenoid you use. These mounts must be stout enough to hold the parts on the gun in the correct position.



Switch and solenoid mount

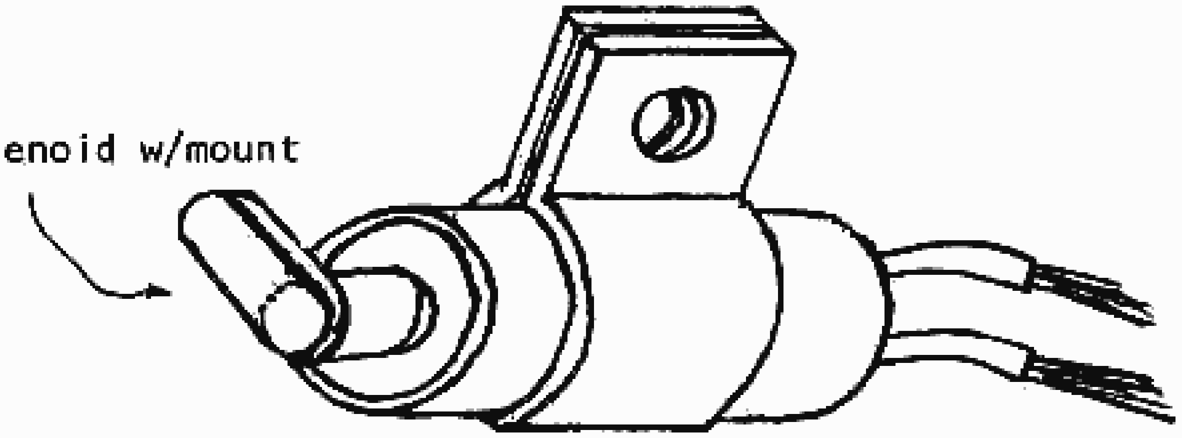
2. The first push button switch must be mounted so that the operating lever of the rifle will push it as the action closes.

3. The solenoid has a metal extension screwed, welded or brazed to the plunger so it will push the trigger when it is activated. The modified unit is now mounted to the trigger guard assembly.

4. The toggle switch and second push switch are the controls and are mounted at your fire control center. In the drawing I show them just under the rifle, but they can be whatever distance you want (such as on the dash of the car).

5. To wire, just follow the pictures, making sure you get the switches in series.

When the wiring is completed, the toggle switch acts as a safety (it must be on for the gun to fire) and when the firing button is pressed, the solenoid will trip the trigger, causing the rifle to fire. When the operating handle goes forward, it presses the switch mounted at the front of the receiver, which causes the solenoid to again trip the trigger. This continues as long as the firing switch is held down or until the ammo runs out.



Solenoid w/mount

This system can be used to secure an approach to your property, such as a driveway or a ditch. You can also mount the system on a T.V. rotor and be able to change the aim. If the gun is mounted in a car or truck, be sure it is very solidly fixed and give close attention to aiming and consider the effect of the car moving.

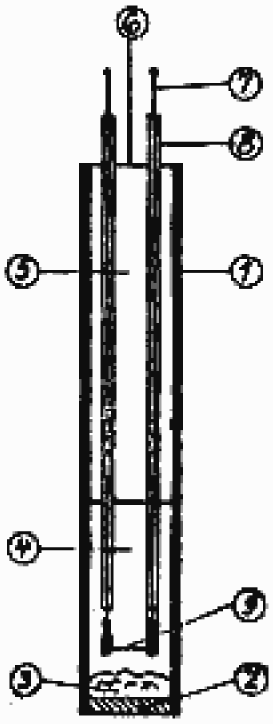
Now you can even fire two weapons in two different directions at once!

IMPROVISED ELECTRIC BLASTING CAPS

How to nitrate mercury:

1. Take a bottle with 1000 cm^3 concentrated, pure nitric acid (spec.weight 1,42). Pour 120 gramms pure mercury into the acid and let it rest for 12 hours. Don't put a stopper on the bottle. After 12 hours put a stopper on it and turn it (acid and mercury shall mix). After some time take the stopper away, because there might be some fumes. Then close the bottle again.

2. Take a big bottle with a large opening with 1280 grams of 95% (pure) alcohol. Pour the mixture of nitric acid and mercury in this bottle. Don't close it. After a short time toxic fumes will escape. When this stops the nitrated mercury will lay on the bottom of the bottle. It must be washed with distilled water and dried in the sun on a glass plate.



1. copperpipe
2. end (soldered)
3. cotton wool
4. mercury, must be nitrated (Knallquecksilber)
5. cotton wool
6. tape
7. electric contacts
8. insulation
9. thin wire (like that in a bulb)

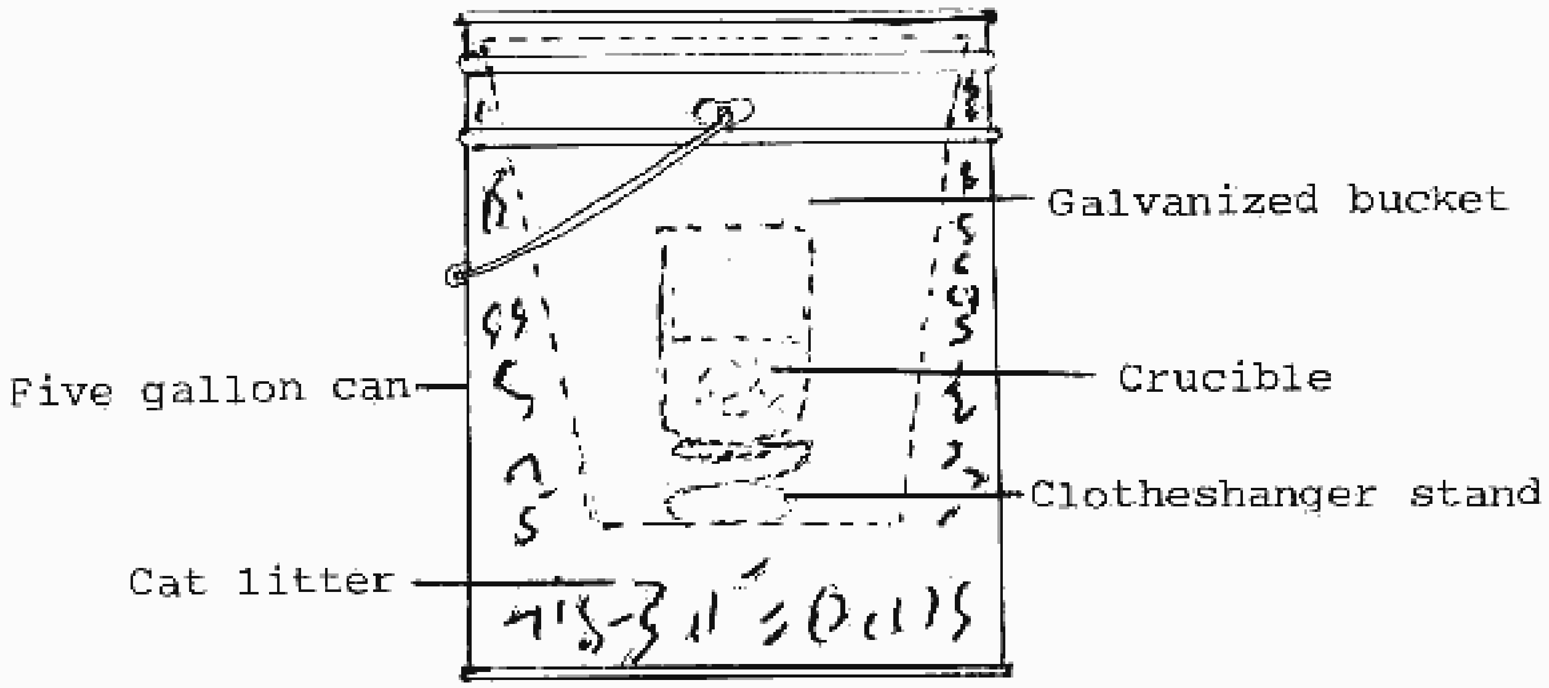
POTASSIUM CYANIDE

In order to make potassium cyanide you must first learn how to make both potassium carbonate and potassium ferrocyanide. If you have some background in chemistry, and especially access to a lab and its equipment, the following processes may at least give you a laugh. And if you're one who believes laypersons should not have access to methods for making such substances, this section should give you the screaming meemies and cold sweats. Because this junkyard lab I'm going to describe really works. If you are the type who likes to fantasize functioning under a totalitarian system which treats everyone like he was either a prison or or a nuthouse inmate, you'll love this.

What with the stigma placed on potassium cyanide by a veritable handful of jerks, it is just about unattainable now. Even though it is not even a controlled substance at this time, I challenge you to get some. I fully expect home chemists to manufacture potassium cyanide and sell it on New York street corners like they do Crack.

At any rate, if you are imaginative and like to learn weird things, turning out your own potassium cyanide will give you a feeling of real importance. It will also teach you more about chemical manipulations than you will learn about in most schools.

These processes may seem time consuming and complicated. However, they are actually very simple. Little time is actually spent, as most of the processes will be working while you are otherwise occupied.



FURNACE

THIS FURNACE, ALONG WITH A HAIR DRYER, ALSO MAKES AN EXCELLENT FORGE FOR METAL WORKING. ITS USE AS A FORGE WOULD ALSO BE AN EXCUSE FOR IT.

With potassium ferrocyanide you can also make prussic acid. To my knowledge, that's the deadliest poison a kitchen chemist can make. Instructions for making it are elsewhere in this book. Its use was demonstrated in the movie, "The Final Option". A terrorist girl was riding a bus in the seat just in front of the intended victim. She had the prussic acid in a perfume atomizer, which can be bought in any department store. Pretending to primp while looking into a hand mirror, she caught his eye and gave him a quick spray in the face, holding her breath in the meantime. One whiff and before he could react he crumpled and died.

Getting back to potassium cyanide; knowledge of how it works might give you the incentive for learning to make it. It acts directly on the nervous system, rapidly. It stops the use of oxygen by the tissue cells and paralyzes the center of the brain which controls the breathing muscles. A fatal dose of cyanide involves about 50 milligrams, about the weight of a postage stamp. Yet this dosage contains close to 10 billion, billion molecules. One molecule of cyanide can disrupt the function of one body cell. A lethal dose, then, affects one out of ten cells in the average human body. Cyanide kills by turning off an enzyme the cell needs to use oxygen from the blood. This enzyme, cytochrome, is vital to the cell's utilization of oxygen. Shut down the action of up to ten percent of a body's cells and death is almost immediate.

Buying potassium cyanide these days is nearly impossible, due to the actions of a few psychotics. These psychotics in our body politic might be compared to cyanide, itself. Whereas just a tiny amount of cyanide is enough to cut off the body's supply of air, a comparable amount of dingbats in a social system is enough to cut off the supply of a chemical once available to all and sold over the counter without questions.

Digressing to a little social comment, I believe society would do better to rid itself of its crazies rather than institutionalizing all of us with bans on guns, chemicals and whatever the psychotic might use next against society. Since looneys have taken to using the telephone to call in threats of tampering and poisoning, we might find soon that our phone privileges are in jeopardy.

At the end of this section are excerpts from 19th century books which describe the making of the chemicals in this section. Modern books guard against such descriptions for reasons of public safety. Of course, in the last century, those who were a threat to public safety were gotten rid of in the interests of the freedom of anyone to have or do whatever he wanted as long as he didn't act to the disadvantage of others. I put the older material here to show how simple these compounds are to make and how casually such knowledge was disiminated among a responsible populace.

Potassium carbonate is gotten from wood ashes. It is the same stuff your great grandmother used to make her lye soap. It is obtained by boiling ashes, letting the ashes settle, pouring off the liquid and evaporating it. It is further refined by heating to over 800 degrees F or more in a furnace, which you can make.

There are several steps to making the grade you need but you can do so with common utensils and little real knowledge of chemistry. The fun of making your own is a feeling of accomplishment and also of security if you like to fantasize getting away with something without anyone knowing.

HOTPLATE

You can do all this work on your kitchen stove but when boilovers occur there is too much screaming and yelling to make your projects worthwhile. Also, there may be times when fumes would be smelly or even dangerous and a hotplate will allow you to run an extension cord outside in the garage or on the back porch.

The kind of hotplate you need is one with a gradual heat control as opposed with one with a single setting or three settings, low, medium and high with nothing in between.

FIVE GALLON CANS

Round, five gallon cans are fine to boil your ashes in and are part of the furnace and have many other uses. Such cans used to be plentiful but since most companies now use plastic the metal ones are hard to find. I called all the places I expected to have them but had no luck until I called my friendly Exxon gas station. Gas stations get grease for lube jobs in the metal cans and give them away. You have but to ask.

They are the very devil to clean as the grease still in them doesn't melt. You can wipe them clean with newspapers and finish with old rags.

ASHES

Wood or coal ashes are both suitable for extracting potassium carbonate from. Coal is simply wood which is maybe fifty million years old. Charcoal ashes are in the same category as wood or coal ashes. You can figure extracting about one pound of potassium carbonate from ten pounds of ashes.

If you have a fireplace or furnace, ashes are no problem. Otherwise, you might ask someone to let you remove their ashes. You will not be refused. Of course, you could always go to some vacant lot, pile up a lot of scrap wood and burn it. Ashes should be no problem.

FIRST STEP

First, put three gallons of hot tap water in one of the cans and put the lid on it. It should boil pretty soon if you put the hotplate dial on full heat. Then the dry ashes, which you have run through a piece of window screen, are put in while stirring. Put in the ashes a pound or so at a time so the heat is kept at a simmer. When the ashes are all in and simmering away, put on the lid and leave it alone for about a half hour. Then remove the lid and stir some more to keep the ashes from lumping on the bottom. Do this every half hour for about three hours, turn off the heat and let the ashes settle overnight.

You should have at least three five gallon cans. Take an old shirt or other cloth and cover the top of the second can. Then wind a turn or so of picture hanging wire or heavy cord around the outer lip of the can, tightly. Then pour off the yellow liquid from the ashes, slowly. When you get to the loose sediment continue pouring. When you get to the heavier sediment, stop, as most of the potassium carbonate has already gone over and what is left is not worth more effort.

Let the loose sediment alone for an hour or so until most of the liquid has gone through the cloth. Then scoop out the sediment from the sagging cloth and remove the cloth.

You should have at least two gallons of yellowish liquid in the can. Put the can on the hotplate and turn it on to full heat. Leave the lid off so the water evaporates. When you have only a couple of quarts left it is time for the first filtering.

FILTERING

Get a coffee filter holder from any supermarket along with a good supply of filters. You can get generic filters for about $1.50 for 200. Put the filter holder and filter on top of a quart jar and slowly pour the liquid from the can into the filter. When the filter gets slightly clogged and you are tired of holding the can, stop, wait for the liquid to go through the first filter and then dispose of the dirty filter.

Pour the filtered liquid into a stew pot or something similar and renew the filter and fill the jar again. Dispose of that filter and continue until there is no liquid or sediment in the can.

Put the pot on the hotplate and set it at a simmer. Watch it pretty closely so all the liquid doesn't evaporate, letting the crude potassium carbonate stick to the pot. When you see crystals forming, that is the time you watch closely because you'll just have to put in more water if it sticks. When it is a mush, put it in the crucible and let it heat until all the moisture is out.

CRUCIBLES

The salts must be melted to fuse and react with the compounds which creates the cyanides. This takes heat at well over 1000 degrees F. The melted salts will go through most clay crucibles and the great heat will melt the seams of most tin cans. You could go to a welding shop and have a four inch wide by six inch long length of steel pipe cut and have a one eigth inch thick steel bottom welded on. This would make an excellent crucible but it would cost maybe five dollars or a little more. If you don't care to pay anything, go to your nearest gas station and get the used oil filters which are thrown away. The largest and most common filters are five inches deep by nearly four inches wide. Their value lies in the fact that they are steel and seamless and free. All you have to do is take a hacksaw and cut around the lip of the filter. Make sure you don't dent the filter or it won't come off. Wipe the oil from it and you will have an excellent crucible which will last through several firings. The larger sizes are best but you may have use for the two smaller sizes. At any rate, the few minutes it takes to cut the case off are well worth the effort.

FIRST FIRING

After the crude potassium carbonate has been well dried in the crucible on the hotplate, it must be fired in the furnace to remove most of the impurities. Never fill the crucible more than half since it tends to bubble up and some would be lost. Since the first firing is while the crucible is completely covered with charcoal or briquets, you must provide the crucible with some sort of cover. If you don't have a jar lid the right size, just cut a circle of tin from a can and cut slices around it so the edges can be bent over, forming an adaquate cover. It doesn't have to fit tightly since it is simply to keep ashes out of the potassium carbonate.

THE FURNACE

A furnace which will serve every purpose in making potassium cyanide can be made with one of the five gallon cans, a galvanized bucket and a 20 pound bag of cat litter. You can get the bucket from any hardware store for under five dollars.

First, pour enough cat litter in the can so the bucket is about an inch from the top of the can. Next, put a piece of thin cardboard between the bucket and the can and pour litter on the cardboard so it fills the space between the bucket and the can. Now you have a furnace which will hold great heat and also will not burn anything outside it. Of course, if your back porch is wooden, set the furnace on a couple of bricks. You can't be too safe.

In your furnace you will also need something to hold the crucible above the first layer of the charcoal briquettes as they don't burn well with the crucible sitting directly on them. This is no problem as you can make a simple stand for the crucible with a clothes hanger. Just bend the clothes hanger around so the the ends nearly touch. Then bend the hook over toward the ends. Put the stand in the bottom of the bucket and sit the crucible on the hook. Bend the stand this way and that until you have it so the crucible will stand straight and about an inch above the bottom layer of briquettes.

Charcoal briquettes are better than regular charcoal because they burn more evenly and last longer. They also throw out less sparks when you are using a hair dryer for white heat. Whatever sparks might blow out are not really dangerous, as they go out within seconds, but you don't want to attract a lot of attention, especially if you are working on a back porch in a city.

The best place to use your furnace is in a garage with the door open so you get plenty of air. Under no circumstances must you use the furnace inside. The carbon monoxide would make you quite ill, if not dead.

Charcoal briquettes are sold at all supermarkets for about $3.00 for 20 pounds. Charcoal lighter is also easily available but I find that a Bernz-O-Matic propane torch with pushbutton lighter to be far superior. You can light the charcoal even faster by simply putting the nozzle of the propane torch down between the briquettes for about a minute. I would suggest you get the bottom layer going, pile in the rest of the briquettes and light them. In a little while, all the briquettes will catch fire and the whole bunch should be glowing with no smoke.

On your first firing of the crude potassium carbonate, pile briquettes in a heap over the covered crucible. Let it burn all night and when you uncover the crucible the next day you'll have what appears to be a mass of fused carbon. If the crucible is still hot, and it probably will be, set it in a pan of water to cool it. If you pour water in it while it is still hot steam and ash will erupt and probably burn your hand.

When the crucible is cool, fill it with water and let it set for a few hours before digging out the contents. This will give the water enough time to dissolve a lot of the purer potassium carbonate hidden in the carbon. When the caked mass can be dumped out of the crucible, put it in two quarts of water and mash and stir it so the potassium carbonate dissolves completely.

Set the two quarts of matter aside until the carbon settles. Then pour the clearer liquid into the filter over the jar. Empty the clear liquid into the pot and set it to simmering so it will evaporate. Here is where you will use up several filters. The liquid goes through very quickly when the filter isn't clogged. Also, a lot of the carbon will go through the filter at first. And when you are to the bottom of the matter and there is mainly carbon left, that will take longest to filter. At any rate, it will all come through clear after a few filterings so don't expect perfect clarity at first. So as a filter empties and what goes through isn't clear, pour it back through another filter and keep it up until it is clear, then evaporate it in the pot.

POTASSIUM FERROCYANIDE

When you have the pretty pure potassium carbonate filtered to clarity and evaporated to a mush, put it in a tin can and put it on the hotplate at medium heat until dry. Since it will stick to the can, take a hammer and bang the can on the sides and bottom to break it loose. It's just a tin can so go ahead and ruin it.

When you have the potassium carbonate out and in chunks, pulverize it to a powder. It will not be crystalized since heating it in the tin can has burned out the water of crystalization. I'm telling you this because when you read the old formulas they tell of crystals and I don't want you to think you have made a mistake. Crystalization is a process manufacturers are set up for but which you don't need.

All right; so you now have some pretty pure anhydrous (without water of crystalization) potassium carbonate. Now for the potassium ferrocyanide. Read the old articles and formulas at the end of this article. Dicks, for instance calls for potassium bicarbonate, to be re-purified to make absolutely pure potassium carbonate. But such purity is for the reagent grade used by chemists for testing and whatever. You don't need 100% pure potassium carbonate or potassium ferrocyanide or even potassium cyanide to anneal with or leach gold from quartz or self-destruct capsules or cyanide grenades or even prussic acid. Read the formula for potassium cyanide from the Techno-Chemical Receipt Book, 1896 to see the garbage which can be used for what you want. You know that wouldn't pass any chemist's test for purity but 400 milligrams of that would make an enemy go belly-up, just the same.

Some of the old formulas call for iron turnings, some call for ferrous oxide (iron oxide or just plain rust). The point is that fused, the atoms of iron will be picked up by the potassium carbonate whether iron turnings or rust is used. Also, you can go to any junk yard and scrape off a lot of rust from old boilers, car bodies or whatever, with a lot less trouble than it takes to turn iron. Use whichever is handy.

Again, some of the old formulas call for coke, cinders or coal, charcoal, blood, hair or leather to add more carbon to the potassium carbonate. So just use five parts of whichever you want. I would choose charcoal but you could get scrap leather from any shoe shop, chop it in small bits and stir it in. The parts referred to mean parts by weight.

So let's get down to the business of making potassium ferrocyanide. Take 10 parts of your homemade potassium carbonate, 10 parts of charcoal or bits of leather and five parts of iron turnings or rust. Get the furnace set up with the bottom layer of charcoal briquettes lit then put the crucible on the coathanger stand. Then pile briquettes all around the crucible and get the rest of them lit. Next, take a regular hair dryer and set it for cool and play the air on the briquettes. You don't want to set the hair dryer on hot since its heat would be negligible but would burn out the unit in a short time. Besides, all you want is the air flow and the dryer can be used indefinately when set on cool. So now you have the briquettes lighted and are training the air flow all over them. You'd be surprized at the difference in heat.

When the crucible turns white hot, pour in the well-mixed ingredients and keep the heat playing around the crucible. I would advise the wearing of glasses and gloves while making potassium ferrocyanide.

Soon the contents will begin to redden and fuse. Take a bent out coathanger wire and stir occasionally. After all flames have ceased in the crucible use a pair of tongs or pliars and lift out the crucible. When the contents have cooled, pour them into two quarts of water and treat as you did while filtering the final processed potassium carbonate. You may want to crystalize it as described in Dick's process further on in number 4201.

POTASSIUM CYANIDE

The last part is a snap. Divide what potassium ferrocyanide you have into eight parts and add three parts by weight of your potassium carbonate. Get your crucible white hot again and pour the mixture in. Very soon it will melt and you will see some slag in the bottom of the crucible. Waiting until all bubbling, simmering or whatever ceases, lift out the crucible and pour the liquid portion into an iron frying pan or onto any hard, cold surface which will not be affected by a molten substance. This will be a pretty pure grade of potassium cyanide. It will not stick and should be broken up and put in an airtight jar. You can get some more potassium cyanide by dissolving and filtering the slag and evaporating the liquid. That's all there is to making potassium cyanide.

DICK'S ENCYCLOPEDIA OF FORMULAS & PROCESSES 1872

4181. Carbonate of Potassa. This is also known under the name *Salt of Tartar*, and *Salt of Wormwood*. The crude carbonate is obtained by lixiviating (*see No.* 23) wood ashes, evaporating the solution to dryness, and fusing in iron pots for several hours. This constitutes the *potash* of commerce.

Another method of preparation is to transfer the product of the first evaporation to an oven or furnace so constructed that the flame is made to play over the alkaline mass, kept constantly stirred with an iron rod. The ignition is continued until the impurities are burned out, and the mass becomes of a bluish-white; this is commercial *pearlash*. The U. S. Pharmacopœia directs, for general purposes, the impure carbonate to be dissolved in water, filtered, and evaporated until it thickens, and then granulated in the manner directed for the pure carbonate.

4182. Pure Carbonate of Potassa. Put 12 troy ounces bicarbonate of potassa, in coarse powder, into a large iron crucible; heat gradually until the water of crystallization is driven off, then raise the heat to redness and maintain it at that heat for 30 minutes. When cool, dissolve it in distilled water, filter, and evaporate over a gentle fire until it thickens, then remove it from the fire and stir it constantly with an iron spatula until it granulates. (*U. S. Ph.*)

4201. Ferrocyanide of Potassium. This *yellow prussiate of potash* is the *prussiate of potash* of commerce. It is obtained by exposing 10 parts potash or pearlash; 10 parts coke, cinders, or coal; and 5 parts iron turnings, all in coarse powder, to a full red heat in an open crucible, stirring occasionally until small jets of purple flame are no longer seen. When cool, the soluble matter is dissolved out of it, the solution filtered, evaporated, and crystallized. The crystals obtained are redissolved in hot water and cooled very slowly, forming large yellow crystals of the ferrocyanide of potassium of commerce. In order to obtain a pure article, fuse effloresced commercial prussiate of potash in a glass vessel, dissolve the fused mass in water, neutralize any excess of alkali with acetic acid, and precipitate the salt with strong alcohol; wash the precipitate with a little weak alcohol, redissolve it in water, and crystallize. (*Cooley.*)

4202. Cyanide (Cyanuret) of Potassium. Mix thoroughly 8 ounces of dry ferrocyanide of potassium and 3 ounces dry carbonate of potassa; throw the mixture into a deep red-hot earthen crucible, the heat being sustained until effervescence ceases, and the fluid portion of the mass becomes colorless; after a few minutes' rest, to allow the contents to settle, the clear portion is poured from the heavy black sediment at the bottom on a clean marble slab; and, while yet warm, broken up and placed in well-closed bottles. When pure, this salt is colorless and odorless, its crystals are cubic or octahedral, and are anhydrous. If it effervesces with acids, it contains carbonate of potassa. If it be yellow, it contains iron. (*Liebig.*)

THE TECHNO-CHEMICAL RECEIPT BOOK 1896

Production of Cyanide of Potassium, Ammonia, Tar, and Gas from Nitrogeneous Organic Substances. Leather waste, blood, wool, hair, etc., are saturated with a solution of potash and then dried. The mass is then heated in retorts, but not to the melting point. Ammonia, gas, and tar are caught up in the usual manner. The residue contains cyanide and cyanate of potassium, sulphocyanide of potassium, calcium carbonate, potassium hydrate, potassium sulphide, and carbon. In the presence of metallic iron or ferrous oxide the cyanide of potassium is converted into ferrocyanide of potassium by lixiviation. After separating this the solution may again serve for impregnating nitrogeneous substances. The potassium hydrate present is converted into carbonate by treating the solution with carbonic acid. In case the raw materials are contaminated with sand it is removed by washing with potash-lye.

THE ENCYCLOPEDIA BRITANNICA 1892
See page 95, column right.

POTASSIUM METALS. Under this heading we treat of potassium, rubidium, and cæsium; SODIUM and LITHIUM, being less closely allied to potassium, have special articles devoted to them.

Potassium.—The three metals under consideration are all very widely diffused throughout nature; but only potassium is at all abundant, and therefore we begin with it. The richest natural store is in the ocean, which, according to Bogusiawski's calculation (in his *Oceanographie*) of its total volume and the present writer's analysis of sea water, contains potassium equal to 1141 times 10^{12} tons of sulphate, K_2SO_4. This inexhaustible store, however, is not much drawn upon at present; the "salt-gardens" on the coast of France have lost their industrial importance as potash-producers, if not otherwise, since the rich deposits at Stassfurt in Germany have come to be so largely worked. These deposits, in addition to common salt, include the following minerals:—sylvine, KCl; carnallite, $KCl.MgCl_2 + 6H_2O$ (transparent deliquescent crystals, often red with diffused oxide of iron); kainite, $K_2SO_4.MgSO_4.MgCl_2 + 6H_2O$ (hard crystalline masses, permanent in the air); kieserite (a hydrated sulphate of magnesia which is only *very slowly* dissolved by water); besides boracite, anhydrite ($CaSO_4$), and other minor components lying outside the subject of this article. The potassium minerals named are not confined to Stassfurt; far larger quantities of sylvine and kainite are met with in the salt-mines of Kalusz in the eastern Carpathian Mountains, but they have not yet come to be worked so extensively. The Stassfurt potassiferous minerals owe their industrial importance to their solubility in water and consequent ready amenability to chemical operations. In point of absolute mass they are insignificant compared with the abundance and variety of potassiferous silicates, which occur everywhere in the earth's crust; orthoclase (potash felspar) and potash mica may be quoted as prominent examples. Such potassiferous silicates are found in almost all rocks, if not as normal at least as subsidiary components; and their disintegration furnishes, directly or indirectly, the soluble potassium salts which are found in all fertile soils. These salts are sucked up by the roots of plants, and by taking part in the process of nutrition are partly converted into oxalate, tartrate, and other organic salts, which, when the plants are burned, assume the form of carbonate, K_2CO_3. It is a remarkable fact that, although in a given soil the soda may predominate largely over the potash salts, the plants growing in the soil take up the latter by preference: in the ashes of most land plants the potash (calculated as K_2O) forms upwards of 90 per cent. of the total alkali (K_2O or Na_2O). The proposition holds, in its general sense, for sea plants likewise. In ocean water the ratio of soda (Na_2O) to potash (K_2O) is 100 : 3·23 (Dittmar); in kelp it is, on the average, 100 : 5·26 (Richardson). Ashes particularly rich in potash are those of burning nettles, wormwood (*Artemisia Absinthium*), tansy (*Tanacetum vulgare*), fumitory (*Fumaria officinalis*), tobacco. In fact the ashes of herbs generally are richer in potash than those of the trunks and branches of trees; yet, for obvious reasons, the latter are of greater industrial importance as sources of carbonate of potash.

Carbonate of Potash (K_2CO_3) in former times used to be made exclusively from wood-ashes, and even now the industry survives in Canada, Russia, Hungary, and other countries, where wood is used as the general fuel. In some places—for instance, in certain districts of Hungary—wood is burned expressly for the purpose; as a rule, however, the ashes produced in households form the raw material. The ashes are lixiviated with water, which dissolves all the carbonate of potash along with more or less of chloride, sulphate, and a little silicate, while the earthy phosphates and carbonates and other insoluble matters remain as a residue. The clarified solution is evaporated to dryness in iron basins and the residue calcined to burn away particles of charcoal and half-burned organic matter. In former times this calcination used to be effected in iron pots, whence the name "potashes" was given to the product; at present it is generally conducted in reverberatory furnaces on soles of cast-iron. The calcined product goes into commerce as crude potashes. The composition of this substance is very variable,—the percentage of real K_2CO_3 varying from 40 to 80 per cent. The following analysis of an American "potashes" is quoted as an example.

Carbonate of potash	...71·4	Water	4·5
,, soda	...... 2·3	Insoluble matter	2·7
Sulphate of potash	......14·4		
Chloride of potassium...	3·6		98·9

Crude potashes is used for the manufacture of glass, and after being causticized for the making of soft soap. For many other purposes it is too impure and must be refined, which is done by treating the crude product with the minimum of cold water required to dissolve the carbonate, removing the undissolved part (which consists chiefly of sulphate), and evaporating the clear liquor to dryness in an iron pan. The purified carbonate (which still contains most of the chloride of the raw material and other impurities) is known as "pearl ashes."

Large quantities of carbonate used to be manufactured from the aqueous residue left in the distillation of beetroot spirit, *i.e.*, indirectly from beetroot molasses. The liquors are evaporated to dryness and the residue is ignited to obtain a very impure carbonate, which is purified by methods founded on the different solubilities of the several components. Such potashes, however, is exceptionally rich in soda: Grandeau found in crude ashes from 16 to 21 per cent. of potash and from 23 to 50 of soda carbonate. This industry would have expired by this time were it not that the beetroot spirit residues are worked for trimethylamine (see METHYL, vol. xvi. p. 196), and the carbonate thus obtained incidentally. Most of the carbonate of potash which now occurs in commerce is made from Stassfurt chloride by means of an adaptation of the "Leblanc process" for the conversion of common salt into soda ash (see SODIUM).

Chemically pure carbonate of potash is best prepared by the ignition of pure bicarbonate (see below) in iron or (better) in silver or platinum vessels, or else by the calcination of pure bitartrate (see TARTARIC ACID). The latter operation furnishes an intimate mixture of the carbonate with charcoal, from which the carbonate is extracted by lixiviation with water and filtration. The filtrate is evaporated to dryness (in iron or platinum) and the residue fully dehydrated by gentle ignition. The salt is thus obtained as a white porous mass, fusible at a red heat (838° C., Carnelley) into a colourless liquid, which freezes into a white opaque mass. The dry salt is very hygroscopic; it deliquesces into an oily solution ("oleum tartari") in ordinary air. 100 parts of water dissolve—

at 0° C.	20° C.	135° C. (boiling point of saturated solution)
83	94	205

parts. Carbonate of potash, being insoluble in strong alcohol (and many other liquid organic compounds), is much used for the dehydration of the corresponding aqueous preparations. From its very concentrated solution in hot water the salt crystallizes on cooling with a certain proportion of water; but these crystals are little known even to chemists. Pure carbonate of potash is being constantly used in the laboratory, as a basic substance generally, for the disintegration of silicates, and as a precipitant. The industrial preparation serves for the making of flint-glass, of potash soap (soft soap), and of caustic potash. It is also used in medicine, where its old name of "sal tartari" is not yet quite obsolete.

Bicarbonate of Potash ($K_2OCO_2 + H_2OCO_2 = 2KHCO_3$) is obtained when carbonic acid is passed through a cold solution of the ordinary carbonate as long as it is absorbed. If silicate is present, it likewise is converted into bicarbonate with elimination of silica, which must be filtered off. The filtrate is evaporated at a temperature not exceeding 60° or at most 70° C.; after sufficient concentration it deposits on cooling anhydrous crystals of the salt, while the chloride of potassium, which may be present as an impurity, remains mostly in the mother-liquor; the rest is easily removed by repeated recrystallization. If an absolutely pure preparation is wanted, it is best to follow Wöhler and start with the "black flux" produced by the ignition of pure bitartrate. The flux is moistened with water and exposed to a current of carbonic acid, which, on account of the condensing action of the charcoal, is absorbed with great avidity. The rest explains itself. Bicarbonate of potash forms large monoclinic prisms, permanent in the air. 100 parts of water dissolve—

at 0°	10°	20°	60°	70°
19·61	23·23	26·91	41·35	45·24

parts of salt. At higher temperatures than 70° the solution loses carbonic acid quickly. The solution is far less violently alkaline to the taste and test-papers than that of the normal carbonate. Hence it is preferred in medicine as an anti-acid. When the dry salt is treated it breaks up below redness into normal carbonate, carbonic acid, and water.

Caustic Potash (*Hydrate of Potassium*), KHO.—It has been known for a long time that a solution of carbonate of potash becomes more intensely alkaline, acts more strongly on the epidermis, and dissolves fats more promptly after it has been treated with slaked lime. It used to be supposed that the latent fire in the quick-lime went into the "mild" alkali and made it "caustic," until Black, about the middle of last century, showed that the chemical difference between the two preparations is that the mild is a compound of carbonic acid and the caustic one of water with the same base (potash),—the causticizing action of the lime consisting in this, that it withdraws the carbonic acid from the alkali and substitutes its own water. Add to this that the exchange takes place only in the presence of a sufficient proportion of water, and that it is undone if the mixture is allowed to get concentrated by evaporation beyond a certain (uncertain) point, and you have a full theory of the process. A good concentration is twelve parts of water for one of carbonate of potash; the lime is best employed in the shape of a semi-fluid paste, made by slaking quick-lime with three parts of water poured on at a time. The alkali solution is heated to boiling in a cast-iron vessel (industrially by means of steam-pipes) and the lime paste added in instalments until a sample of the filtered mixture no longer effervesces on addition of an excess of acid. The mixture is then allowed to settle in the iron vessel, access of air being prevented as much as practicable, and the clear liquor is drawn off by means of a syphon. The remaining mud of carbonate and hydrate of lime is washed, by decantation, with small instalments of hot water to recover at least part of the alkali diffused throughout it, but this process must not be continued too long or else some of the lime passes into solution. The united liquors are boiled down in an iron vessel until the desired degree of concentration is reached. In obedience to an old tradition, the concentration is habitually continued until the specific gravity of the cold ley is 1·333, which is a rather inconveniently high degree of strength for most purposes, but in the case of the ordinary commercial article offers this advantage, that any sulphate of potash which may be present as an impurity crystallizes out completely on standing (Liebig). If solid caustic potash is wanted, the ley (after removal of the deposit of sulphate, &c.) is transferred to a *silver* dish, and the evaporation continued until, instead of steam, the heavy vapour of KHO itself is seen to go off. The residual oily liquid is then poured out into a polished iron tray, or into an iron mould to produce the customary form of "sticks," and allowed to cool. The solidified preparation must be at once bottled up, because it attracts the moisture and carbonic acid of the air with great avidity and deliquesces. According to the present writer's experience (*Journ. Soc. Chem. Ind.*, May 1884), nickel basins are far better adapted than iron basins for the concentration of potash ley. The latter begin to oxidize before the ley has come up to the traditional strength, while nickel is not attacked so long as the percentage of *real* KHO is short of 60. For the fusion of the dry hydrate nickel vessels cannot be used; in fact, even silver is perceptibly attacked as soon as *all* the excess of water is away; absolutely pure KHO can be produced only in *gold* vessels. Regarding the action of potash on platinum, see PLATINUM (*supra*, p. 191). Glass and (to a less extent) porcelain are attacked by caustic potash ley, slowly in the cold, more readily on boiling.

Frozen caustic potash forms an opaque, white, stone-like mass of dense granular fracture; specific gravity = 2·1. It fuses considerably below and is perceptibly volatile at a red heat. It is extremely soluble in even cold water, and in any proportion of water on boiling. The solution is intensely "alkaline" to test-papers. It readily dissolves the epidermis of the skin and many other kinds of animal tissue,—hence the well-known application of the "sticks" in surgery. A dilute potash ley readily emulsionizes fats, and on boiling saponifies them with formation of a soap and of glycerin. Caustic potash is the very type of an energetic (mono-acid) basic hydrate (see CHEMISTRY, vol. v. pp. 486, 488).

According to Tünnermann's and Schiff's determinations, as calculated by Gerlach, the relation in pure potash ley between specific gravity at 15° C. and percentage strength is as follows:—

Percentages of KHO or K_2O.	Specific Gravity, if percentage refers to		Percentages of KHO or K_2O.	Specific Gravity, if percentage refers to	
	K_2O.	KHO.		K_2O.	KHO.
0	1·000	1·000	25	1·285	1·230
1	1·010	1·009	30	1·355	1·288
10	1·099	1·083	40	1·504	1·411
15	1·154	1·128	50	1·660	1·539
20	1·215	1·177	60	1·810	1·667

All commercial caustic potash is contaminated with excess of water (over and above that in the KHO) and with carbonate and chloride of potassium; sulphate, as a rule, is absent. Absolutely pure potash has perhaps never been seen; a preparation sufficing for most purposes of the analyst is obtained by digesting the commercial article in strong (85 per cent. by weight) *pure* alcohol. The hydrate KHO dissolves in the alcohol of the solvent; the chloride and the carbonate unite with the water and form a lower layer or magma, from which the alcoholic solution of the KHO is decanted off, to be evaporated to dryness and fused in silver vessels ("potasse à l'alcool").

The metal (potassium) has been known to exist since Lavoisier, but was first obtained as a substance by Humphry Davy in 1807. He prepared it from the hydrate by electrolysis. Gay-Lussac and Thénard subsequently found that this substance can be reduced to the metallic state more easily by passing its vapour over white hot metallic iron; but even their method as a mode of preparation was soon superseded by Brunner's, who, to the surprise of his contemporaries, produced the metal by simply distilling its carbonate with charcoal—applying an old-established principle of ordinary metallurgy. Brunner's process is used to the present day for the production of the metal.

One of those cylindrical, neckless, wrought-iron bottles which serve for the storing of quicksilver is made into a retort by taking out the screw-plug at the centre of one of the round ends and substituting for it a short, ground-in, iron outlet pipe. This retort is charged with a black flux made from a mixture of pure and crude bitartrate so adjusted that the flux contains as nearly as possible the proportion of free carbon demanded by the equation $K_2CO_3 + 2C = 2K + 3CO$. It is then suspended horizontally within a powerful wind-furnace, constructed for coke as fuel. At first a mixture of coke and charcoal is applied, to produce the right temperature for chasing away the moisture and enabling one to, so to say, varnish over the retort with borax and thus protect it against the subsequent intense heat. After these preliminaries coke alone is used and the fire urged on to, and maintained at, its maximum pitch, when potassium vapour soon begins to make its appearance. The condensation of this vapour, however, demands special methods, because even the cold metal would quickly oxidize in the air and act most violently on liquid water. Brunner used to condense the vapour by passing it into a small copper vessel charged with rock-oil (see PARAFFIN, vol. xviii. p. 237), in which liquid the condensed metal sinks to the bottom and thus escapes the air. Donné and Maresca dispense with rock-oil altogether; they receive the vapour in a dry condenser made of two flat rectangular trays of wrought iron which fit closely upon each other, enclosing a space such as might be used as a mould for casting a thin cake of any ordinary metal. This condenser has a short neck into which the outlet pipe of the retort fits; and the pipe must be as short as possible, because it is essential (Donné and Maresca) that the hot vapour pass abruptly from its original high to a low temperature, to evade a certain range of medium temperatures at which the metal combines with carbonic oxide into a black solid, which may obstruct the outlet pipe. The formation of this bye-product cannot be altogether avoided; hence a long borer is inserted into the condenser from the first to enable one to clear the throat of the retort at a moment's notice. The condenser is kept as far as possible cold by the constant application to it of damp cloths. As soon as the distillation is finished the (still hot) condenser is plunged into a bucketful of rock-oil, to cool it down, the mould opened (under the oil), and the now solid metal taken out. The crude metal is always contaminated with some of the black solid and other mechanical impurities. To remove these the best method is to redistil it from out of a small iron retort and condense the vapour in rock-oil according to Brunner's original plan. The purified metal is soft enough to be moulded (under rock-oil) into globular pieces, which are preserved in bottles filled to the top with the protecting liquid. But even this does not prevent gradual oxidation; bright metallic potassium can be maintained in this condition only by preserving it in a sealed-up glass tube within a vacuum or in an atmosphere of hydrogen or some other inert gas. The black solid above referred to is a most dangerous substance. When exposed to the air it turns red and then explodes either spontaneously or on the slightest provocation by friction or pressure. Even if kept under rock-oil it gradually becomes explosive. The distillation of potassium, in fact, is a dangerous operation, which had better be left in the hands of specialists.

Pure potassium is a bluish-white metal; but on exposure to ordinary air it at once draws a film of oxide, and on prolonged exposure deliquesces into a solution of hydrate and carbonate. At temperatures below 0° C. it is pretty hard and brittle; at the ordinary temperature it is so soft that it can be kneaded between the fingers and cut with a blunt knife; specific gravity = 0·865. It fuses at 62°·5 C. (Bunsen), and at 720° to 730° C. (Carnelley and Williams), *i.e.*, considerably below its boiling point, begins to distil with formation of an intensely green vapour. When heated in air it fuses and then takes fire and burns into a mixture of oxides. Most remarkable, and characteristic for the group it represents, is its action on water. A pellet of potassium when thrown on water at once bursts out into a violet flame and the burning metal fizzes about on the surface, its extremely high temperature precluding absolute contact with the liquid, except at the very end, when the last remnant, through loss of temperature, is wetted by the water and bursts with explosive violence. What really goes on chemically is that the metal decomposes the water thus, $K + H_2O = KHO + H$, and that the hydrogen catches fire, the violet colour of the flame being due to the potassium vapour diffused throughout it. Similar to that on water is its action on alcohol: the alcohol is converted into ethylate, while hydrogen escapes, $K + C_2H_5 . OH = C_2H_5 . OK + H$, this time without inflammation. So strong is the basilous character of the element that, in opposition to it, even ammonia behaves like an acid. When the oxide-free metal is heated gently within the dry gas it is gradually transformed into a blue liquid, which on cooling freezes into a yellowish-brown or flesh-coloured solid. This body is known as "potassamide," KNH_2. When heated by itself to redness the amide is decomposed into ammonia and nitride of potassium, $3NH_2K = NK_3 + 2NH_3$. The nitride is an almost black solid. Both it and the amide decompose water readily with formation of ammonia and caustic potash. Potassium at temperatures from 200° to 400° C. "occludes" hydrogen gas, as palladium does (see "Palladium," under PLATINUM, *supra*, p. 193). The highest degree of saturation corresponds approximately to the formula K_2H for the "alloy," or to about 126 volumes of gas (measured cold) for one volume of metal. In a vacuum or in sufficiently dilute hydrogen the compound from 200° upwards loses hydrogen, until the tension of the free gas has arrived at the maximum value characteristic of that temperature (Troost and Hautefeuille).

Potassium Oxides, singularly, can be produced only from the metal, and another remarkable fact is that the one with which all chemical students imagine they are so familiar—namely, "anhydrous potash," K_2O—is little more than a fiction. According to Vernon Harcourt, when the metal is heated cautiously, first in dry air and then in dry oxygen, it is transformed into a white mass (K_2O_2 ?), which, however, at once takes up more oxygen with formations ultimately of a yellow powdery tetroxide (K_2O_4), fusible at a red heat without decomposition. At a white heat it loses oxygen and leaves a residue of lower oxides (K_2O ?). When heated in hydrogen it is reduced to ordinary potash, KHO. When dissolved in excess of dilute acid it yields a mixed solution of the respective potash salt and peroxide of hydrogen, with abundant evolution of oxygen gas.

Potassium Salts.—There is only one series of these known,—namely, the salts produced by the union of potash (KHO) with acids.

Chloride, KCl.—This salt (commercial name, "muriate of potash") is at present being produced in immense quantities at Stassfurt from the so-called "Abraumsalze." For the purpose of the manufacturer of muriate these are assorted into a raw material containing approximately in 100 parts—55-65 of carnallite (representing 16 parts of chloride of potassium); 20-25 of common salt; 15-20 of kieserite, a peculiar, very slowly soluble sulphate of magnesia, $MgSo_4 . H_2O$; 2-4 of tachhydrite ($CaCl_2 . 2MgCl_2 + 12H_2O$); and minor components. This mixture is now wrought mainly in two ways. (1) The salt is dissolved in water with the help of steam, and the solution is cooled down to from 60° to 70°, when a quantity of impure common salt crystallizes out, which is removed. The decanted ley deposits on cooling and standing a 70 per cent. muriate of potash, which is purified, if desired, by washing it by displacement with cold water. Common salt principally goes into solution, and the percentage may thus be brought up to from 80 to 95. The mother-liquor from the 70 per cent. muriate is evaporated down further, the common salt which separates out in the heat removed as it appears, and the sufficiently concentrated liquor allowed to crystallize, when almost pure carnallite separates out, which is easily decomposed into its components (see *infra*). (2) Ziervogel and Tuchen's method. The crude salt is ground up and then heated in concentrated solution of chloride of magnesium with mechanical agitation. The carnallite principally dissolves and crystallizes out relatively pure on cooling. The mother-liquor is used for a subsequent extraction of fresh raw salt. The carnallite produced is dissolved in hot water and the solution allowed to cool, when it deposits a coarse granular muriate of potash containing up to 99 per cent. of the pure substance. The undissolved residue produced in either process consists chiefly of kieserite and common salt. It is worked up either for Epsom salt and common salt, or for sulphate of soda and chloride of magnesium. The potassiferous bye-products are utilized for the manufacture of manures.

Chemically pure chloride of potassium is most conveniently prepared from pure perchlorate (see *infra*) by dioxygenating it in a platinum basin at the lowest temperature and then fusing the residue in a well-covered platinum crucible. The fused product solidifies on cooling into a colourless glass. Chloride of potassium dissolves in water and crystallizes from the solution in anhydrous cubes. 100 parts of water dissolve—

at 0°	10°	20°	50°	100° C.
29·2	32·0	34·7	42·8	56·6

parts of the salt. When a sufficiency of hydrochloric-acid gas is passed into the solution the salt is completely precipitated as a fine powder. If the original solution contained chloride of magnesium or calcium or sulphate of potash, all impurities remain in the mother-liquor (the SO_3 as $KHSO_4$), and can be removed by washing the precipitate with strong hydrochloric acid. Chloride of potassium fuses at 738° C. (Carnelley), and at a red heat volatilizes rather abundantly.

Chlorate, $KClO_3$.—This industrially important salt was discovered in 1786 by Berthollet, who correctly designated it as "peroxidized muriate." Chlorine gas is largely absorbed by cold caustic-potash ley with formation of chloride and hypochlorite, $2KHO + Cl_2 = KCl + KClO + H_2O$. When the mixed solution is boiled it suffers, strictly speaking, a complicated decomposition, which, however, in the main comes to the same as if the hypochlorite broke up into chloride and chlorate, $3KClO = 2KCl + KClO_3$. Hence chlorate of potash is easily produced by passing chlorine into hot caustic-potash ley so as at once to realize the change, $6KHO + 3Cl_2 = 3H_2O + 5KCl + KClO_3$; and this method used to be followed industrially until Liebig pointed out that five-sixths of the potash can be saved by first substituting milk of lime, $Ca(OH)_2 = 2caOH$, for the potash ley and from the mixed solution of lime-salts precipitating, so to say, the chloric acid as potash salt by adding 1KCl for every $1caClO_3$ present, concentrating by evaporation, and allowing the $KClO_3$ to crystallize out. This is the present industrial process. For the technical details we must refer to the handbooks of chemistry. Suffice it to say that in practice about 1·03 times KCl are used for every $1caClO_3$, and that the s. * produced is almost chemically pure after one recrystallization. By repeated recrystallization every trace of impurities is easily removed. The crystals are colourless transparent monoclinic plates, which, unless formed very slowly, are very thin, so as often to exhibit the Newton's colours. 100 parts of water dissolve—

at 0°	15°	50°	104°·8 (on boiling)
3·3	6	19	60

parts of the salt (Gay-Lussac). The salt is almost insoluble in strong alcohol. It is permanent in the air. It fuses at 359° C. (Carnelley), and at about 18° above the temperature of its formation the liquid gives off oxygen *with evolution of heat*, and formation ultimately of chloride (and oxygen). The salt accordingly, in opposition to any combustible matter with which it may be mixed, behaves at the same time as a store of highly-condensed loosely-combined oxygen and of potential heat. Hence its manifold applications in artillery and pyrotechnics are easily understood. To give one example of the readiness with which it acts as a burning agent: a mixture of it and sulphur when struck with a hammer explodes loudly, the mechanical blow sufficing to produce locally the temperature necessary for starting the reaction. When the salt was still a novelty it was tried as a substitute for the nitre in gunpowder. Such powder, however, proved too good to be safe. More recently a mixture of 49 parts of the chlorate, 23 of sugar, and 28 of prussiate of potash was recommended by Pohl as a preferable substitute for gunpowder, but this powder has never come into actual use anywhere. We must not forget to point out that mixtures of chlorate of potash and combustible substances must on no account be made in a mortar; this would be sure to lead to dangerous explosions. The several ingredients must be powdered separately and only then be mixed together on a sheet of paper or on a table, all unnecessary pressure or friction being carefully avoided.

The decomposition of chlorate of potash by heat is greatly facilitated by admixture of even small proportions of certain solid oxides, *e.g.*, oxide of copper, of iron, or of manganese. The oxygen, in the case of binoxide of manganese, for instance, comes off below the fusing point of the salt. Hence a salt contaminated with even a small proportion of heavy metallic chlorate cannot (in general) be fused without decomposition. The writer observed this anomaly with a commercial chlorate which happened to contain about one half per cent. of chlorate of zinc. The aqueous solution of the salt is neutral and bears prolonged boiling without decomposition. On acidification with dilute sulphuric acid it assumes the reactions of a solution of chloric acid, *i.e.*, of a powerful but readily controllable oxydant. In this capacity it is used in calico-printing as a "discharge." In the same industry it serves for making the chlorate of soda needed for the production of aniline black. In the chemical laboratory it is in constant requisition as a source of oxygen and as an oxidizing agent. In the hands of Marignac it served for the determination of the important ratio KCl : 3O.

Perchlorate, $KClO_4$.—The decomposition of chlorate of potash by heat, if catalytic agents like MnO_2, &c., are absent, proceeds by two stages. In the first the salt breaks up thus, $2KClO_3 = KCl + O_2 + KClO_4$; in the second the perchlorate at a higher temperature is decomposed into chloride and oxygen. The termination of the first stage is marked by a slackening in the evolution of the oxygen and by the residual salt (which, at the beginning, is a thin fluid) becoming pasty. From the mixture $KCl + KClO_4$ the chloride is extracted by lixiviation with successive instalments of cold water. The residual perchlorate is *very easily* purified by recrystallization (compare pure chloride of potassium, *supra*). Perchlorate of potash dissolves in 88 parts of water of 10°C., and in far less of boiling water. It is absolutely insoluble in absolute alcohol. It begins to give off its oxygen at about 400° C., which is below its fusing point. The salt has been recommended as a substitute for chlorate in pyrotechnic mixtures, because it contains more oxygen, and yet, on account of its greater stability, is a less dangerous ingredient.

Bromide, KBr.—This salt is formed when bromine is dissolved in caustic-potash ley. The reaction is quite analogous to that going on in the case of chlorine; only the hypobromite (KBrO) first produced is far less stable than hypochlorite, and vanishes after short heating. The addition of bromine is continued until the liquid is permanently yellow and retains its colour after short heating. The solution is then evaporated to dryness and the bromate decomposed by cautious heating. A small portion of the bromate breaks up into $K_2O + Br_2 + 5O$; hence the residual bromide is contaminated with a little free alkali; but this is easily set right by neutralizing its solution with hydrobromic acid. The salt crystallizes in colourless transparent cubes, easily soluble in water. It is used in medicine for quieting the nerves,—to cure sleeplessness, for instance; also (internally) as a local anæsthetic preparatory to operations on the larynx or the eye. The dose of the pure (KI free) salt for adults can safely be raised to 2 grammes (about 30 grains). It is also used in photography.

Iodide, KI.—Of the very numerous methods which have been recommended for the preparation of this important salt the simplest (and probably the best) is to dissolve in a caustic-potash ley (which is dilute enough to hold the rather difficultly soluble iodate KIO_3 in solution) enough iodine to produce a permanent yellow colour (the iodine passes at once into $5KI + KIO_3$; the hypo body KIO has no existence practically) and to deoxidize the iodate, which is done most conveniently by adding a sufficiency of powdered charcoal to the solution, evaporating to dryness in an iron vessel, and heating the residue. The oxygen goes off as CO_2 at a lower temperature than that which would be needed for its expulsion as oxygen gas. The residue is dissolved, and the solution filtered and evaporated to crystallization. The salt comes out in colourless transparent cubes, very easily soluble in even cold water. The commercial salt forms opaque milk-white crystals, which, as a matter of habit, are preferred to the clear salt, although they are produced by causing the salt to crystallize from a strongly alkaline solution and by drying the crystals (finally) in a stream of hot air, and although through the former operation they are at least liable to contain carbonate. Iodide of potassium acts far more powerfully on the human system than bromide, and therefore is administered in smaller doses. It is used against skin-diseases, and also for eliminating the mercury which settles in the system after long-continued administration of mercurial medicines. It is also used, far more largely than the bromide, in photography. See PHOTOGRAPHY, *passim*.

Sulphate (K_2SO_4) used to be extracted from kainite, but the process is now given up because the salt can be produced cheaply enough from the muriate by decomposing it with its exact equivalent of oil of vitriol and calcining the residue. To purify the crude product it is dissolved in hot water and the solution filtered and allowed to cool, when the bulk of the dissolved salt crystallizes out with characteristic promptitude. The very beautiful (anhydrous) crystals have as a rule the habitus of a double six-sided pyramid, but really belong to the rhombic system. They are transparent, very hard, and absolutely permanent in the air. They have a bitter salty taste. 100 parts of water dissolve—

at 0°	12°	100° C.
8·36	10	26

parts of the salt. Sulphate of potash fuses at a strong red heat, and at this temperature volatilizes, for an alkaline salt, rather slowly. The chloride, weight for weight, volatilizes at ten times the rate (Bunsen). Sulphate of potash used to be employed in medicine, but is now obsolete. The crude salt is used occasionally in the manufacture of glass.

Bisulphate ($KHSO_4$) is readily produced by fusing thirteen parts of the powdered normal salt with eight parts of oil of vitriol. It dissolves in three parts of water of 0° C. The solution behaves pretty much as if its two congeners, K_2SO_4 and H_2SO_4, were present side by side of each other uncombined. An excess of alcohol, in fact, precipitates normal sulphate (with little bisulphate) and free acid remains in solution. Similar is the behaviour of the fused dry salt at a dull red heat; it acts on silicates, titanates, &c., as if it were sulphuric acid raised beyond its natural boiling point. Hence its frequent application in analysis as a disintegrating agent.

For the following potash salts we refer to the articles named:—*Chromates*, see CHROMIUM; *Cyanide* and *Ferrocyanide*, PRUSSIC ACID; *Chloroplatinate*, PLATINUM (*supra*, p. 192); *Nitrate*, NITROGEN (vol. xvii. p. 518); *Phosphates*, PHOSPHORUS (vol. xviii. pp. 818-19); *Oxalates*, OXALIC ACID; *Sulphides* and *Sulphites*, SULPHUR; *Silicates*, GLASS (vol. x. p. 655 *sq.*) and SILICA; *Tartrates*, TARTARIC ACID. For potash salts not named, see the handbooks of chemistry.

Rubidium and Cæsium.—When Bunsen and Kirchhoff in 1860 applied their method of spectrum analysis to the alkali salts which they had extracted analytically from Dürkheim mineral water they obtained a spectrum which in addition to the lines characteristic for sodium, potassium, and lithium, exhibited two blue lines which were foreign to any other spectrum they had ever seen. They accordingly concluded that these lines must be owing to the presence of a new alkali metal, which they called "cæsium." Bunsen at once resumed the preparation of the mixed alkaline salt with 44,000 litres of Dürkheim water, with the view of isolating the cæsium in the form of a pure salt; and he was more than successful—for the new alkali salt, after elimination of all the ordinary alkali metals, proved to be a mixture of the salts of *two* new alkali metals, which he succeeded in separating from each other. For one he retained the name already chosen; the other he called "rubidium," on account of the presence in his spectrum of certain characteristic red lines. Since Bunsen's time these two metals have been discovered in a great many native potassiferous materials—minerals, mineral waters, plant ashes, &c.—but in all cases they form only a small fraction of the alkali, the cæsium in general amounting to only a fraction of even the rubidium. One solitary exception to both rules is afforded by a rare mineral called "pollux," which is found only on the island of Elba. Plattner analysed this mineral in 1846 and recognized it as a compound silicate of alumina, oxide of iron, soda, potash, and water; but his quantitative analysis came up to only 92·75 per cent., and he could not account for the 7·25 per cent. of loss. After Bunsen's discovery Pisani analysed the mineral again, and he found that it contained no potash at all, but, instead of it, a large percentage (34·1) of *cæsia*. Recalculating Plattner's analysis on the assumption that the presumed chloroplatinate of potassium was really chloroplatinate of cæsium, he found that the corrected numbers did add up to near 100 and agreed with his own. Rubidium, singularly, is absent from this mineral.

That both rubidium and cæsium are contained in sea water might well be taken for granted; but it is worth while to state that Schmidt of Dorpat actually proved the presence of rubidium, and even determined it quantitatively.

For the preparation of rubidium compounds one of the best materials is a mixture of alkaline salts, which falls as a bye-product in the industrial preparation of carbonate of lithia from lepidolite. A supply of this salt mixture which Bunsen worked up contained 20 per cent. of chloride of rubidium, 33 of chloride of potassium, and 36 of common salt, but very little cæsium; his supply came from the Saxon or Bohemian mineral. The lepidolite of Hebron, Maine, United States, on the other hand, is rich in cæsium. Another practically available source for cæsium is the mother-liquor salt of Nauheim in Germany. It yielded to Böttcher 1 per cent. of its weight of the chloroplatinate $PtCl_6Cs_2$.

Bunsen's method for the extraction of the two rare potassium metals from a given mixture of alkaline salts is founded upon the different solubility of the several alkaline chloroplatinates. According to him 100 parts of water dissolve—

	Potassium	*Rubidium*	*Cæsium*
at 0° C.	0·74	0·13	0·024
,, 20° C.	1·12	0·14	0·079
,, 100° C.	5·13	0·[illegible]	0·377

parts of the several salts. The chloroplatinates of sodium and lithium are easily soluble even in cold water, so that chloride of platinum does not precipitate these two metals at all. Hence, supposing we boil a given mixture of chloroplatinates of potassium and (say) rubidium with a quantity of water insufficient to dissolve the whole, part of both salts will dissolve; but the residual chloroplatinate will be richer in rubidium than the dissolved part. And supposing, on the other hand, we add to a mixed solution of the two chlorides a quantity of chloroplatinic-acid solution insufficient to bring down the whole of both metals, the rubidium will accumulate in the precipitate and the potassium in the solution.' It is also easily understood that, if the amount of reagent added falls short even of that which would be needed by the rubidium if present alone, a very nearly pure $PtCl_6Rb_2$ may be expected to come down. Any dry chloroplatinate is easily reduced to a mixture of metallic platinum and alkaline chloride by the simple operation of heating in hydrogen to about 300° C. The chloride can be dissolved out, and thus again made amenable to fractional precipitation by platinum solution, and the platinum be reconverted into reagent by means of aqua regia. Hence the process is not so expensive as it might at first sight appear.

Redtenbacher has worked out an analogous process to Bunsen's, founded upon the different solubility of the three alums—$Al.R(SO_4)_2 + 12H_2O$. At 17° C. 100 parts of water dissolve of the alum of

Potassium	*Rubidium*	*Cæsium*
13·5	2·27	0·62

parts. Sodium and lithium alum are very easily soluble in water, and remain dissolved in the first mother-liquor when the mixed alum of K, Rb, and Cs crystallizes out. These three alums are parted by repeated crystallization, and the rare alkalis recovered from their respective alums by precipitation with chloride of platinum.

The separation of rubidium and cæsium offers great difficulties. According to Godeffroy an approximate separation may be effected by dissolving the mixed chlorides in strong hydrochloric acid, and adding a solution of terchloride of antimony in the same menstruum; the cæsium (chiefly) comes down as $SbCl_3 + 6CsCl$; the bulk of the rubidium remains dissolved. The two rare alkali metals are so closely similar to potassium that it will suffice to give a tabular statement of the principal points of difference. By way of introduction, however, we may state that rubidium metal was prepared by Bunsen from the black flux obtained by igniting the bitartrate, by Brunner's method for potassium. Metallic cæsium, it seems, cannot be thus obtained; but in 1883 Setterberg made it by the electrolysis of a fused mixture of the cyanides of cæsium and barium.

	Potassium.	*Rubidium.*	*Cæsium.*
Atomic weights O=16	K=39·136	Rb=85·4	Cs=133·0
Free Metals—			
Specific gravity	0·865	1·52	1·88
Fusing point	62°·5	38°·5	26° to 27° C.
Volatility increases →			
Hydrates, RHO—Very similar to one another; the basility increases →			
Chlorides, RCl..........	*Vide supra.* Almost insoluble in alcohol.	Permanent in air. More soluble than KCl. Soluble in alcohol.	Deliquescent.
Sulphates, R_2SO_4—			
100 parts of water dissolve .... At − 2° C.	8	?	159
,, 70° C.	19·8	42	?
Carbonates, R_2CO_3—All very soluble in water.			
100 parts of alcohol dissolve ... . At 19° C.	0	0·74	11·1
Alums *Chloroplatinates*	Solubility decreases → (*vide supra*).		

Analysis.—In this section we treat of the detection and determination of alkali metals generally. If the given substance is a solid, a good preliminary test is to heat about one centigramme of it at one end of a fine platinum wire in the flame-mantle of a Bunsen lamp, or in a blow-pipe flame just at the end of the inner cone. Most alkali salts are sufficiently volatile to impart to the flame the colour characteristic of the respective metallic vapour. Certain native silicates and certain other compounds do not volatilize, but these can be rendered amenable to the test by mixing them with sulphate of lime and then applying the flame, whereupon alkaline sulphate is formed which volatilizes. The flame-colours are—

Potassium, Rubidium, Cæsium.	*Sodium.*	*Lithium.*
Violet.	Yellow.	Red.

These flame-reactions are very delicate but not conclusive, because in the case of mixtures several colours may be radiated out at the same time, and one may eclipse all the rest—this holds, for instance, for things containing sodium, whose flame-colour is more intense than that of any other metal—or a mixed colour may be produced which the eye is incompetent to analyse. The spectrum apparatus here comes in usefully; and by means of it it is in general possible to see the lines characteristic of the several metals in presence of, or at least after, one another, because as a rule the several metals are present as compounds of different volatility.

For a thorough analysis it is necessary to begin by bringing the substance into aqueous or acid solution, and next to eliminate all that is *not* alkali metal by suitable methods. A certain set of heavy metals can be precipitated as sulphides by means of sulphuretted hydrogen in the presence of acid, all the rest of these by means of sulphide of ammonium from an alkaline solution. From the filtrate, barium, strontium, and calcium are easily precipitated by means of carbonate of ammonia on boiling, so that, if the filtrate from these carbonates is evaporated to dryness and the residue kept at a dull red heat long enough to drive away the ammonia salts, nothing can be left but salts of alkali metals and magnesium. This residue is dissolved in a *small* quantity of water, and any residual basic salt of magnesium filtered off. The filtrate is then ready to be tested for alkali metals as follows: *if magnesia be absent*, potassium or rubidium (not cæsium) can be detected by addition (to a neutral or feebly acetic solution) of a saturated solution of bitartrate of soda. Potassium and rubidium come down as crystalline bitartrates. The reaction may take some time to become manifest, but can be accelerated by vigorous stirring. In a separate quantity of the solution lithium may be searched for by means of carbonate of soda or trisodic phosphate as explained under LITHIUM (vol. xiv. p. 697). For soda we have no characteristic precipitant. In any case the spectrum apparatus should be used for controlling and, if necessary, supplementing the wet-way tests. The case of *magnesia being present* need not be specially considered, because the qualitative method will easily be deduced from what is said in the following paragraph.

Quantitative Determinations.—An exhaustive treatment of this subject would be out of place here. We confine ourselves to two cases. (1) A mixture of alkaline chlorides only. In this case the potassium (including Rb and Cs) is best separated out by adding a quantity of chloroplatinic-acid solution sufficient to convert *all the metals* into chloroplatinates, to evaporate to dryness over water-bath, and from the residue to extract the lithium and sodium salts by lixiviation with alcohol of 70 per cent. (by weight). The residual chloroplatinate is collected on a filter, dried at 110° C., and, if Rb and Cs are absent, weighed as chloroplatinate of potassium, $PtCl_6K_2(PtCl_6K_2 \times 0 \cdot 3071 = 2KCl)$. The chloride of sodium is determined by difference—if lithium be absent. The case of its presence cannot be here considered. (2) A mixture of alkalis combined with sulphuric acid, or such volatile acids as can be expelled by sulphuric. In this case it is best to begin by converting the whole into neutral sulphates, and then to apply the method of Finkener, which, amongst other advantages, offers the one that it does *not* demand the absence of magnesia. The mixed sulphate is dissolved in water and the solution mixed with a little more than the volume of chloroplatinic acid ("platinum solution") demanded by the potassium (Rb and Cs). The mixture is placed in a water bath and, if necessary, diluted with sufficient water to bring the whole of the precipitated chloroplatinate into hot solution. The solution is then evaporated very nearly to dryness (on the water bath, with continuous stirring towards the end to avoid formation of crusts), allowed to cool, and the residue mixed, first with twenty times its volume of absolute alcohol, then with ten volumes of absolute ether. The mixture is allowed to stand in a well-covered vessel for some hours, to enable the precipitate to settle completely. The precipitate contains all the potassium as chloroplatinate, and most of the sodium and magnesium, and also part of the lithium in the sulphate form. It is washed with ether-alcohol (to complete filtrate A), and then lixiviated as quickly as possible with cold concentrated solution of sal-ammoniac, which dissolves away the sulphates (filtrate B). The residual chloroplatinate is dried within the filter in a porcelain crucible, which is next heated so as to char the paper at the lowest temperature. The residue is then ignited gently in hydrogen, and from the resulting residue the chloride of potassium is extracted by water, to be determined as chloroplatinate, as shown in (1), or otherwise. From the undissolved residue the charcoal is burned away and the residual platinum weighed to check the potassium determination. After removal of the ether and alcohol from filtrate A by distillation, the two filtrates A and B are mixed, evaporated to dryness, the ammonia salts chased away by heating, and the residue is reduced (at about 300° C.) in hydrogen to bring the platinum into the form of metal, from which the magnesia and alkali salts are easily dissolved away by means of water or dilute acid. The whole of the salts are then made into neutral sulphate, which is weighed and then dissolved in a known weight of water. The lithium and the magnesium are determined in aliquot parts of the solution and calculated as sulphates. The soda is found by difference. A case intermediate between (1) and (2) often presents itself in practice. We refer to the commercial muriate from Stassfurt. In such an impure muriate the potassium can be determined promptly and accurately by adding to the very concentrated solution of the substance a large excess of a very concentrated solution of chloroplatinic acid,—"excess" meaning more platinum than necessary to make all the metals into chloroplatinates. The precipitate is allowed to settle, collected on a small filter, and washed, first with successive instalments of a platinum solution (containing 5 per cent. of metal), then with ordinary alcohol; it is next dried, and weighed as above (Tatlock's method slightly modified). In exact analyses the small quantity of potassium which passes into the filtrate is recovered—ultimately by Finkener's method—and allowed for.

Cyanogen, $(NC)_2$.—When dry mercuric cyanide is heated it breaks up, below redness, into mercury and cyanogen gas; part of the latter, however, always suffers polymerization into a solid called "paracyanogen," and presumed to consist of molecules $(NC)_3$. Cyanogen gas is colourless; it has the specific gravity demanded by its formula. It possesses a peculiar odour and has a characteristic irritating effect on the eyes and mucous membranes of the nose. It is poisonous. By strong pressure it is condensible into a liquid which freezes at −34°·4 C., and has the following vapour-tensions *P* at the temperatures *t* stated—

$t =$	−20°·7	−10°	0°	+10°	+20° C.
$P =$	1	1·85	2·7	3·8	5 atmos.

At ordinary temperatures water dissolves about 4·5 times, alcohol about 23 times its volume of the gas. The solutions are liable to (very complex) spontaneous decomposition. The list of products includes oxalate of ammonia and urea. Cyanogen burns with a characteristically beautiful peach-blossom coloured flame into carbonic acid and nitrogen. This gas cyanogen, as already stated, is to cyanides what chlorine gas Cl_2 is to chlorides, but it is well to remember that the analogy, though perfect in regard to the corresponding formulæ, does *not*, as a rule, extend to the conditions of formation of the bodies represented. Thus cyanogen does not unite with hydrogen into prussic acid, nor does it combine with ordinary metals in the chlorine fashion. When passed over heated potassium, it is true, it combines with it into cyanide; and caustic potash-ley absorbs it with formation of cyanide and cyanate (NCO.K), just as chlorine yields chloride and hypochlorite KClO; but this is about the sum-total of the analogies in action. Yet metallic cyanides of all kinds can be produced indirectly.

Cyanide of Potassium, NC.K.—An aqueous mixture of the quantities NCH and KHO no doubt contains this salt, but it smells of the acid, and on evaporation behaves more like a mixture of the two congeners than in any other way. An exhaustive union can be brought about by passing NCH vapour into an alcoholic solution of KHO; the salt NC.K then comes down as a crystalline precipitate, which must be washed with alcohol and dried, cold, over vitriol. A more convenient method is to dehydrate yellow prussiate and then decompose it by heating it to redness in an iron crucible. The $Fe(NC)_2$ part of the salt breaks up into cyanogen and nitrogen, which go off, and a carboniferous finely-divided iron, which remains, with cyanide of potassium, which at that temperature is a thin fluid. Yet the iron sometimes refuses to settle with sufficient promptitude to enable one to decant off the bulk even of the fused cyanide. According to private information received by the writer a French manufacturer uses a certain kind of very porous fireclay as an efficient filtering medium.

The ordinary "cyanide of potassium" of trade is not strictly that at all, but at best a mixture of the real salt with cyanate. It is produced by fusing a mixture of eight parts of anhydrous prussiate and three parts of anhydrous carbonate of potash, allowing the reaction

$$(NC)_6Fe.K_4 + K_2CO_3 = CO_2 + Fe + 5NCK + \underset{\text{Cyanate}}{K.NCO}$$

to complete itself and the iron to settle, and decanting off the clear fuse. The product goes by the name of "Liebig's cyanide," but the process was really invented by Rodgers.

Fused cyanide of potassium assumes on cooling the form of a milky white stone-like solid. It fuses readily at a red heat, and at a white heat volatilizes without decomposition, provided that it is under the influence of heat alone; in the presence of air it gradually passes into cyanate; when heated in steam it is converted into carbonate of potash with evolution of ammonia, carbonic oxide, and hydrogen. When heated to redness with any of the more easily reducible metallic oxides it reduces them to the metallic state, while it passes itself into cyanate. It also reduces the corresponding sulphides with formation of sulphocyanate; for example, Pb(S or O) + NCK = Pb + NC(O or S)K. Hence its frequent application in blowpipe analysis. When heated with chlorates or nitrates it reduces them with violent explosion. The aqueous solution of the salt has a strongly alkaline reaction; it smells of hydrocyanic acid and is readily decomposed by even such feeble acids as acetic or carbonic. It readily dissolves precipitated chloride, bromide, and iodide of silver; this is the basis of its application in photography. Large quantities of the salt are used in electroplating.

Other Binary Cyanides.—Of these only a few can be noticed here. (1) *Cyanide of sodium* is very similar to the potassium salt. The same remark, in a more limited sense, holds for the cyanides of barium, strontium, and calcium. (2) *Cyanide of ammonium* ($NC.NH_4$) forms crystals volatile at 36° C. and smelling of ammonia and hydrocyanic acid. The solution in water decomposes spontaneously, pretty much like that of the free acid. But the anhydrous vapour by itself stands a high temperature, as is proved by the fact that it is produced largely when ammonia is passed over red-hot charcoal, $C + 2NH_3 = H_2 + NCH.NH_3$. (3) *Mercuric cyanide*, $Hg(NC)_2$, forms very readily when mercuric oxide is dissolved in aqueous prussic acid. The solution on evaporation and cooling deposits crystals soluble in eight parts of cold water. This salt is not at all decomposed, even when heated, by water, nor appreciably by dilute sulphuric or nitric acid; boiling hydrochloric acid eliminates the NC as hydrocyanic acid; sulphuretted hydrogen acts similarly in the cold. It gives no precipitate with nitrate of silver, nor is it changed visibly by caustic alkalis. It readily unites not only with other cyanides but also with a multitude of other salts into crystallizable double salts. Mercurous cyanide, $Hg_2(NC)_2$, seems to have no existence. When it is attempted to produce it by double decompositions, the mixture $Hg + (NC)_2Hg$ comes forth instead of the compound $Hg_2(NC)_2$. (4) Heavy metallic cyanides are mostly insoluble in water, and the general method for their preparation is to decompose a solution of the respective sulphate, chloride, &c., with one of cyanide of potassium. The most important general property of these bodies is that they readily dissolve in solution of cyanide of potassium with formation of double cyanides, which in their capacity as double salts all exhibit, in a higher or lower degree, those anomalies which were fully explained above (see "prussiate of potash"). These "metallo-cyanides," as we will call them, being all, unlike plain cyanide of potassium, very stable in opposition to water and aqueous alkalis, are readily produced from almost any compound of the respective metallic radical—some from the metal itself—by treatment with solution of cyanide of potassium. In all we have said "potassium" may be taken as including sodium and in a limited sense ammonium, but the potassium compounds are best known, and we accordingly in the following section confine ourselves to these.

Metallo-cyanides.—(1) *Silver.*—Cyanide of silver, $Ag.NC$, is produced as a precipitate by addition of hydrocyanic acid or cyanide of potassium to solution of nitrate of silver. The precipitate is similar in appearance to chloride of silver and, like it, insoluble in cold dilute mineral acids, but soluble in ammonia. At a red heat it is decomposed with formation of a residue of carboniferous metallic silver.

Precipitated cyanide of silver, though insoluble in hydrocyanic acid, dissolves readily in cyanide of potassium with formation of argento-cyanide, $AgK.(NC)_2$, which is easily obtained in crystals, permanent in the air and soluble in eight parts of cold water. Chloride of silver dissolves in cyanide of potassium solution as readily as the cyanide does and with formation of the same double salt—$AgCl + 2KNC = KCl + AgK(NC)_2$. This salt is used very largely in electro-plating. (2) *Lead.*—From a solution of the acetate cyanide of lead is precipitated by addition of hydrocyanic acid or cyanide of potassium. The precipitate, $Pb(NC)_2$, has the exceptional property of being insoluble in cyanide of potassium. (3) *Zinc.*—Cyanide of zinc, $Zn(NC)_2$, is obtained by addition of hydrocyanic acid to a solution of the acetate, as a white precipitate readily soluble in cyanide of potassium with formation of a double salt, $ZnK_2(NC)_4$, which forms well-defined crystals. (4) *Nickel.*—The cyanide, $Ni(NC)_2$, is an apple-green precipitate, which is obtained by methods similar to those given under "zinc." It readily dissolves in cyanide of potassium with formation of a crystallizable salt, $NiK_2(NC)_4 + H_2O$, the solution of which is stable in air and not convertible into one of a nickelic (Ni''') compound by chlorine (compare "cobalt" *infra*). The potassio-cyanides of silver, zinc, and nickel as solutions are not changed visibly by caustic alkalis, but their heavy metals can be precipitated by sulphuretted hydrogen or sulphide of ammonium, as from solutions of, for instance, the chlorides. Aqueous mineral acids (in the heat at least) decompose them exhaustively with elimination of all the NC as NCH. (5) *Copper.*—When cyanide of potassium solution is added to one of sulphate of copper, a yellow precipitate of cupric cyanide, $Cu(NC)_2$, comes down; but on boiling this precipitate loses cyanogen and is converted into a white precipitate of the cuprous salt $Cu(NC)$. This white precipitate dissolves in cyanide of potassium with formation chiefly of two crystalline double salts, viz., $CuNC + 6NCK$, easily soluble in water, and $CuNC + NC$[illegible]. The latter [illegible]posed by water with elimination of $Cu.NC$. The solution of the $6NC.K$ salt is *not* precipitated by sulphuretted hydrogen. Solutions of potassio-cyanides of cuprosum are used in electro-plating. (6) *Gold.*—Metallic gold dissolves in cyanide of potassium solution in the presence of air, thus—

$$Au + 2KNC + \tfrac{1}{2}O = \tfrac{1}{2}K_2O + AuK.(NC)_2.$$

This auro-cyanide of potassium is used largely for electro-gilding, for which purpose it is conveniently prepared as follows. Six parts of gold are dissolved in aqua regia and the solution is precipitated by ammonia. The precipitate (an explosive compound known as "fulminating gold") is dissolved in a solution of six parts of cyanide of potassium, when the double salt is formed with evolution of ammonia. The salt crystallizes in rhombic octahedra, soluble in seven parts of cold water.

In the following potassio-cyanides the heavy metals cannot be detected by means of their ordinary precipitants; these salts all behave like the potassium salts of complex radicals composed of the heavy metal and all the cyanogen. (7) *Cobalt.*—Cyanide of potassium when added to a solution of a cobaltous salt ($CoCl_2$, &c.) gives a precipitate soluble in excess of reagent. The solution presumably contains a cobalto-cyanide, $Co(NC)_2.xKNC$, but on exposure to air eagerly absorbs oxygen with formation of cobalti-cyanide, thus—

$$Co(NC)_2 + 4KNC + \tfrac{1}{2}O = \tfrac{1}{2}K_2O + Co'''(NC)_3\ 3KNC.$$

Chlorine (Cl instead of $\tfrac{1}{2}O$) acts more promptly with a similar effect. If the alkaline solution is acidified and boiled, the same cobalti-cyanide is produced with evolution of hydrogen—.

$$Co(NC)_2 + 4KNC + HCl = KCl + \tfrac{1}{2}H_2 + Co'''(NC)_3.3KNC.$$

Cobalti-cyanide of potassium, $(NC)_6Co'''.K_3$, forms yellow crystals isomorphous with those of red prussiate (see *infra*). It is a remarkably stable salt. In its behaviour to reagents it exhibits none of the characters of a cobalt salt or of a simple cyanide. Aqueous mineral acids convert it into the hydrogen salt $(NC)_6Co'''H_3$, which remains undecomposed on boiling. Heavy metallic salts produce precipitates of cobalti-cyanides; for example, $(NC)_6Co'''.Ag_3$. (8) *Ferrosum.*—See "prussiate of potash" above. (9) *Ferricum.*—Ferric hydrate and ferric compounds generally do not act upon cyanide of potassium in a manner analogous to that of ferrous compounds; but a ferri-cyanide analogous to the cobalti-salt referred to in (7) is readily produced by passing chlorine into a cold solution of ordinary prussiate, $(NC)_6Fe''.K_4 + Cl = KCl + (NC)_6fe'''.K_3$.[1] In preparing the salt an excess of chlorine and elevation of temperature must be avoided, or else part of the salt is decomposed with formation of a green precipitate. The solution on evaporation and cooling yields splendid dark red crystals, soluble in 2·54 parts of water of 15°·6 C. (Wallace), forming a most intensely yellow solution. (Ordinary prussiate solution is only pale yellow even when saturated in the cold.) This salt (discovered by L. Gmelin in 1822) is now being manufactured industrially and is known in commerce as "red prussiate." In its reactions it is analogous to ordinary yellow prussiate. The same group, $(NC)_6Fe$, which in the latter acts as a four-valent, in the red salt plays the part of a tri-valent radical, $(NC)_6fe$. But the radical thus modified has a great tendency to assume the four-valent form; hence an *alkaline* solution of red prussiate is a powerful oxidizing agent, $(NC)_6fe.K_3 + KHO = (NC)_6Fe.K_4 + HO$. The HO goes to the reducing agent. Like the yellow salt, red prussiate is not poisonous, at least when pure.

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[1] Here we use the symbol "fe" as designating 56 parts of ferric iron,—"Fe" meaning the same quantity of ferrosum.

Ferro- and Ferri-cyanides of Iron.—The two prussiates are constantly being used in the laboratory as very delicate reagents for the detection of iron salt, and for the discrimination of ferrous and ferric compounds in solutions,—(1) ferro-cyanide and ferrous salt, white precipitate; (2) ferri-cyanide and ferric salt, intensely brown coloration; (3) ferro-cyanide and ferric salt, blue precipitate; (4) ferri-cyanide and ferrous salt, blue precipitate. These blue precipitates are being produced industrially and used as pigments, under the names of "prussian blue" and "Turnbull's blue" for (3) and (4) respectively. The latter has been thus known for now half a century; yet the constitution of the precipitates and the true rationale of their formation have been fully cleared up only during the last few years. The main results of the researches referred to are included in the following paragraphs.

(1) *Ferro-cyanide of Hydrogen*, $(NC)_6Fe.H_4$, is obtained as a white crystalline precipitate when air-free concentrated solution of yellow

precipitate is mixed with hydrochloric acid and ether. It is easily soluble in water and in alcohol. An aqueous solution of it is prepared for technical purposes by mixing a strong solution of yellow prussiate with enough tartaric acid to bring down the potassium as cream of tartar. When the solution of this ferro-hydrocyanic acid is boiled half the cyanogen goes off as NCH, while the other remains as part of a white, rather unstable, precipitate, $(NC)_6Fe\,.\,\genfrac{}{}{0pt}{}{Fe}{H_2}$. When the solution is exposed to the air, especially at higher temperatures, part of the cyanogen goes off as NCH, another part suffers oxidation into $H_2O + NC$, and this latter combines with the $Fe(NC)_2$ of the original compound into blue bodies similar in their general properties to prussian blue. This latter change is utilized in calico-printing for producing patterns of, or dyeing with, prussian blue. The white precipitate $(NC)_6Fe\,.\genfrac{}{}{0pt}{}{Fe}{H_2}$ may be looked upon as an acid of which

(2) *Everett's Salt*, $(NC)_6Fe\,.\,\genfrac{}{}{0pt}{}{Fe}{K_2}$, is the potash salt. This salt is produced in the ordinary process for making prussic acid (see above). It is probably identical with the white precipitate produced when ferrous salt is decomposed by prussiate of potash. Everett's salt when exposed to the air quickly absorbs oxygen and becomes blue; the reaction, as Williamson showed, assumes a simple form when the precipitate is boiled with nitric acid. One-half of the potassium is then oxidized away, and a blue double ferri-cyanide of potassium and ferrosum takes the place of the original precipitate:—

$$(NC)_6Fe\,.\,K_2Fe = \tfrac{1}{2}(K_2O \text{ as nitrate}) + \underset{\text{Williamson's blue.}}{\{(NC)_6fe\}'''Fe''K'}.$$

This blue when boiled with ferro-cyanide of potassium is reconverted into the original Everett's salt with formation of a solution of red prussiate—

$$(NC)_6fe\ \ KFe^* + K_2{}^*K_2\,.\,Fe(NC)_6 = \underset{\text{Red prussiate.}}{(NC)_6fe\,.\,K_3} + \underset{\text{Everett's salt.}}{Fe(NC)_6\,.\,FeK_2},$$

the asterisked radicals changing places.

(3) *Soluble Prussian Blue* is *isomeric* with Williamson's blue. It is produced by mixing a solution of ferric salt with *excess* of yellow prussiate, which, however, is an old process; what has been ascertained lately is that the very same precipitate is produced by addition to a ferrous salt of an excess of red prussiate.

$$\text{I. } (NC)_6fe\,.\,K_3 + FeCl_2 = 2KCl + (NC)_6fe\,.\,KFe = B'.$$
$$\text{II. } (NC)_6Fe\,.\,K_4 + feCl_3 = 3KCl + (NC)_6Fe\,.\,Kfe = B''.$$

B′ and B″ in the formulæ look different, but the difference is only apparent; in either case the group $(NC)_6$ is combined with 1Fe and 1fe and 1K; the bodies are identical (Skraup; Reindel). The precipitate B, though insoluble in salt solutions, is soluble in pure water, forming an intensely blue solution; hence the name.

Now the potassium in soluble prussian blue can be displaced by iron in two ways, namely, by digestion with solutions of ferrous or ferric salts. In the former case $(NC)_6feFeK$ becomes $(NC)_6feFe_{\frac{3}{2}}$, or empirically $(NC)_{12}Fe_5$; this is Gmelin's ("Turnbull's") blue. In the latter case $(NC)_6FefeK$ becomes $(NC)_6Fefe_{\frac{4}{3}}$, or empirically $(NC)_{18}Fe_7$; this is prussian blue as discovered by Diesbach. Contrasting this latter formula with that of Gmelin's blue $(NC)_{18}Fe_{7\frac{1}{2}}$, we see that the latter needs only lose ½Fe to become prussian blue; this surplus iron in fact can be withdrawn by means of nitric acid.

In the manufacture of prussian blue the general process is to first precipitate ferrous sulphate with yellow prussiate and then to fully oxidize the precipitate by means of nitric acid or chlorine as far as the oxygen of the air does not do it. The following receipt is recommended amongst others. Six parts each of green vitriol and yellow prussiate are dissolved separately, each in fifteen parts of water, and the solutions mixed. One part of concentrated sulphuric acid and twenty-four parts of fuming muriatic acid are then added, and after standing some hours also a solution of bleaching powder in instalments until the blue colour is fully developed. "Turnbull's" blue is made by precipitating red prussiate of potash with excess of ferrous salt; but it is easily seen from what was said above that the use of this relatively expensive double cyanide might be dispensed with. The properties of the two pigments are pretty much the same. They are sold in the form of solid cakes or lumps, which, in addition to their blue colour, present a coppery lustre on fracture. They are stable against acids, but sensibly affected (bleached) on prolonged exposure to sunlight; and, although they stand neutral soap fairly well, they are decomposed promptly by solutions of even the carbonates of the alkalis with formation of hydrated oxides of iron. The cheaper commercial varieties are more or less largely diluted with clay, sulphate of baryta, &c. Pure prussian blue dissolves readily in a dilute solution of oxalic acid; the intensely blue solution used to serve as a blue ink, but has come to be superseded by the several more brilliant blues of the coal-tar series. These tar-blues have displaced prussian blue also in other applications, and as a commercial pigment it has besides to struggle against ultramarine. In short, it has gone very much out of use, and as a consequence the manufacture of yellow prussiate is no longer so remunerative as it used to be.

Analysis of Cyanides.—As hydrocyanic acid and cyanide of potassium are dangerously poisonous, and the latter at least is easily procured in commerce, the detection of cyanogen in this state of combination is one of the problems of forensic chemistry. To detect such cyanogen in, say, the contents of a stomach the first step is to distil the mass after acidification with tartaric acid, which decomposes cyanide of potassium but does not liberate prussic acid from prussian blue (or even prussiate of potash?). If the distillate gives *no* precipitate with nitrate of silver hydrocyanic acid is absent, if it does the precipitate may have been produced by hydrochloric acid, which may then be eliminated by redistillation with borax or sulphate of soda, neither of which affects NCH. But even in the presence of chlorides the following two tests give perfect certainty. (1) A solution of hydrocyanic acid, when alkalinized with caustic potash and then mixed with, first ferroso-ferric salt and then excess of hydrochloric acid, gives a precipitate, or at least a green suspension, of prussian blue. (2) A solution of NCH, when mixed with ammonia and yellow sulphide of ammonium, is changed into one of sulphocyanate of ammonium, which, after removal of the excess of reagents by evaporation at a gentle heat, strikes an intense and very characteristic red colour with ferric salts, which colour does *not* vanish (as that of ferric acetate does) on even strong acidification with mineral acid (Liebig's test). The *quantitative* determination of cyanogen given as an aqueous solution of hydrocyanic acid or cyanide of potassium can (if haloids are absent) be effected by adding excess of nitrate of silver, then acidifying, if necessary, with nitric acid, filtering off, washing, drying, and weighing the cyanide of silver produced. AgNC = 134 corresponds to NCH = 27 parts. A more expeditious method has been invented by Liebig. A known quantity of the given prussic acid is alkalinized strongly with caustic potash and then diluted freely with water. The caustic alkali usually contains plenty of chloride as an impurity, else a little alkaline chloride must be added. A standard solution of nitrate of silver (conveniently adjusted so as to contain 6·30 grammes of fused nitrate per 1000 cubic centimètres, equivalent to 2 grammes of NCH) is now dropped in from a burette until the cloud of chloride of silver which appears locally from the first just fails to disappear on stirring, *i.e.*, until the reaction $2KNC + AgNO_3 = KAg.(NC)_2 + KNO_3$ has just been completed. One cub. cent. of silver solution used indicates 2 milligrammes of NCH. Liebig's method lends itself particularly well for the assaying of the medicinal acid and of cyanide of potassium. The two tests for hydrocyanic acid given above apply as they stand to solutions of the cyanides of alkali and alkaline-earth metals, but *not* to mercuric cyanide. In regard to all other cyanides we have only space to say that from a certain set (which includes the cobalti-cyanides and the platinum cyanides) cyanogen cannot be extracted at all as NCH (or AgNC) by any known methods. Such bodies must be identified by their own specific reactions or by elementary analysis. All cyanides are decomposed by *hot* concentrated sulphuric acid; the carbon goes off as CO, the nitrogen remains as sulphate of ammonia and the metals as sulphates, which brings them within the range of the routine methods of analysis.

Cyanates.—These were discovered by Wöhler. The potassium salt NCO.K is produced by the oxidation of fused cyanide, for preparative purposes most conveniently by Wöhler's method. An intimate mixture of two parts of absolutely anhydrous prussiate of potash and one part of equally dry binoxide of manganese is heated on an iron tray until the mass has become brownish black and just begun to fuse. It is now allowed to cool and exhausted by boiling 80 per cent. alcohol. The filtrate on cooling deposits crystals of the salt NCO.K. If only an aqueous solution of this salt is wanted for immediate use, the fuse may be extracted by *cold* water. From this solution the cyanate of silver, NCO.Ag, or lead, $(NCO)_2Pb$, can be prepared by precipitation with solutions of the respective nitrates or acetates. *Hot* water decomposes cyanate of potash promptly with formation of carbonates of potash and ammonia,

$KNCO + 2H_2O = NH_3 + KHO + CO_2$. On addition of mineral acid to even the cold solution only a very little of the cyanic acid is liberated as such; the bulk breaks up at once with effervescence, thus, $NCO.H + 2H_2O = NH_3 + CO_2 + H_2O$. Very interesting is the action of the solution of cyanate of potash on sulphate of ammonia; its direct effect is the formation of cyanate of ammonia, $NCO.NH_4$, but this salt almost immediately passes spontaneously into its isomer urea, which is not a cyanate at all but the amide of carbonic acid, *i.e.*, $CO(OH)_2 - 2(OH) + 2NH_2 = CO\begin{smallmatrix}NH_2\\NH_2\end{smallmatrix}$. This reaction was discovered by Wohler, who thus for the first time produced an organic substance from inorganic materials, or virtually from its elements. Singularly, it is this pseudo-cyanate urea which serves as a material for making cyanic acid. When hydrochlorate of urea, $HCl.CON_2H_4$, is heated to 145° C. the latter behaves as if it were cyanate of ammonia: the ammonia unites with the hydrochloric acid into sal-ammoniac and the cyanic acid is set free, but immediately suffers polymerization into cyanuric acid, a solid tri-basic acid of the composition $N_3C_3O_3H_3$, which, being difficultly soluble, can be freed from the sal-ammoniac by being washed with cold water. If perfectly anhydrous cyanuric acid be subjected to dry distillation it furnishes a distillate of (liquid) cyanic acid $NCO.H$, which must be condensed in a vessel surrounded by a freezing mixture.

Cyanic acid has a very appreciable vapour-tension even at ordinary temperatures, and the least trace of its vapour makes itself felt by a characteristically violent and dangerous action on the respiratory organs. With dry ammonia gas it unites into true cyanate of ammonia. We do not know much of its own properties, because as soon as it comes out of the freezing mixture it begins to suffer polymerization into "cyamelid" with great evolution of heat. This cyamelid is a porcelain-like mass, insoluble in all ordinary solvents and devoid of acid properties. Dry distillation reconverts it into cyanic acid.

Thiocyanates.—This term means bodies like cyanates, but containing sulphur instead of the oxygen of the latter. Thiocyanates are better known, however, as sulphocyanates or sulphocyanides. (1) The potassium salt $NCS.K$ is formed when cyanide of potassium is fused with sulphur or certain metallic sulphides, *e.g.*, PbS. The usual method of preparation is to fuse together forty-six parts of dehydrated yellow prussiate of potash, seventeen of dry carbonate of potash, and thirty-two of sulphur. The fuse is exhausted with boiling alcohol and the filtered solution allowed to cool, when crystals of the salt separate out. The salt is very soluble in water with characteristically large absorption of heat. (2) The ammonium salt $NCS.NH_4$ can be prepared by allowing a mixture of alcohol, strong aqueous ammonia, and bisulphide of carbon to stand for a time and then warming it. Thiocarbonate of ammonium, $CS_2.(NH_4)_2S$, is produced first, but subsequently it gives up $2H_2S$ to the ammonia and becomes $NCS.NH_4$, which is easily obtained in crystals. The tar water obtained in the manufacture of coal-gas sometimes contains sufficient quantities of this salt to make it worth while to recover it. Both the potassium and the ammonium salt are much used as reagents, and more especially as precipitants for copper and silver. Solutions of cupric salt when mixed with sulphocyanate assume the dark-brown colour of the cupric salt $Cu(NCS)_2$, but on addition of sulphurous acid the colour disappears and a white precipitate of cuprous sulphocyanide, $NCS.Cu$, comes down, which, if enough of reagent was used, contains all the copper. If sulphocyanate is added to nitrate of silver, all the silver is precipitated as $Ag.NCS$, similar in appearance to the chloride and, like it, insoluble in water and in nitric acid. Upon this and the fact that sulphocyanates strike a deep red colour with ferric salts Volhard has based an excellent titrimetric method for the determination of silver. (See SILVER.)

Syntheses of Cyanogen Compounds.—Synthetical organic chemistry dates from Wöhler's discovery of the artificial formation of urea, and in the further development of this branch of the science cyanogen has played a prominent part. (For illustrations we may refer to certain passages in the present article and in those on METHYL and on NITROGEN.) Hence it is worth while to enumerate briefly the synthetical method for the making of cyanogen itself. (1) Hydrocyanic acid is produced when a current of electric sparks is made to cross a mixture of acetylene, C_2H_2, and nitrogen. (2) Cyanide of ammonium is formed when ammonia is passed over red-hot charcoal (see *supra*). (3) Metallic cyanides are produced when dry nitrogen gas is passed over a dry mixture of carbonate of potash or baryta and charcoal at a white heat. A similar reaction goes on spontaneously in the iron-smelting furnaces and gives rise to the formation of vapour of cyanide of potassium. (4) Sulphocyanide of ammonium is produced from bisulphide of carbon and ammonia, as explained above.

SPORTING GOODS STORE SLINGSHOT IS LETHAL

A new weapon adopted by Militants is the "Whamo" sling shot. Its steel pellets will penetrate a human skull. It can even deliver many types of bombs.

Its arrow attachment allows a Militant to sit in a car and fire an arrow with enough force to kill. While spectators are looking for a man with a bow, the killer drives away. A perfect night weapon.

SINKER BASHER

While at the sporting goods store you might pick up a two-ounce lead fishing sinker. Tie on two feet of strong fish line and make a loop at the end.

To use it, put the loop on your forefinger and hold the sinker and line in the palm of your hand. Then half throw, half swing the sinker at the prey.

With a little practice you can flick it out at a victim's temple and finish him off before he knows you mean to strike. This goody is for close quarter work in crowds, especially at night. They drop like flies and no one knows what hit him.

PLASTIC AUTO BODY FILLER FOR BETTER BOMBS

A plastic substance used to fill out dents in car bodies can also be used to compact simple bombs and replace the screw caps on pipe bombs.

Some of the substance is put on a piece of wood or cardboard. Then a few drops of hardener are added and the stuff is well mixed. It begins to harden in a few minutes so you have to have all your job ready and work fast before the ooky mess gets too stiff to work with.

It sets in a few minutes and then any excess can be pared off with a knife before it gets too hard. It is like rock in 24 hours. In the first few minutes it is sticky and runs, so often molds are used.

A good use for plastic auto body filler is to stop up the ends of pipe bombs. Pipe caps are very expensive and the Militant must be constantly on the alert for ways to cut corners; as who does not in these days of ruinous inflation?

An inch of the filler is enough to cap the ends. Since the glop is sticky and runs, paper wadding is put in the end of the pipe to hold the filler in place until it hardens. The wadding is then removed or packed against the filler with a stick.

First, the wadding is shoved into the pipe so there is a one-inch space. The space is filled with goody which is allowed to harden. Then you remove all the wadding you can or pack it in. Then fill the pipe with explosive to 1½ inches from the top.

Then a fuse is put into the explosive and a small bit of wadding is pressed around it. The filler is poured in and the thing is done.

In order to save a hassle in getting the first batch of wadding out there should be two pieces of wadding. A big gob of wadding should be put in first and a small gob should be put over it. That way, the little gob will be stuck to the filler and the big gob can be removed without trouble.

The chemicals in some brands of auto body filler will deactivate some brands of fuse. If this happens with yours, just twist some plastic from a Baggie around the fuse that will be exposed to the filler.

This method of capping pipe bombs saves more than the price of the caps. It also allows you to use scrap pipe cut to size instead of the more expensive lengths of pipe that are threaded for caps.

Anything you are using the filler on should be free from grease and dirt. Pipes should be boiled in strong soap so the filler will bond with the metal.

As the filler begins to set it becomes quite hot. There is not enough heat to detonate any explosive, but for safety's sake, always use some wadding.

PEOPLE'S GRENADES

A very simple way to make a grenade is to fill a two-ounce bottle with gunpowder or other explosive. The bottle cap is drilled for a fuse. The bottle and part of the fuse is then smeared liberally with plastic auto body filler and laid on a waxed or paper surface and allowed to harden.

THE ULTIMATE BOOBY TRAP

or

Ammonium Nitrogen Tri-Iodide

Every reference I've read concerning ammonium nitrogen tri-iodide has it as an interesting scientific curiosity with no practical application. "ANTI", as I call it; being anti any enemy, is guaranteed to be the most effective booby trap trigger ever discovered.

I got the formula from "Chemical Magic", one of the books in GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY. ANTI is simply iodine crystals soaked in strong ammonia. The book advises making up just a little bit and demonstrating how it can be set off by the touch of a feather. You see, it is an explosive. In fact, it's a high explosive; a fulminate!

The reason other writers have dismissed it as having no practical application is probably because they don't think along the lines of improvised weaponry. But I do. I made about a teaspoonful and spread it about an eighth of an inch thick on my work table and let it dry. Then I barely touched it with a feather. Instead of the snap-crackle-pop effect described in the book, it was a real explosion. The table was pitted and my ears rang. After having made far more than required to demonstrate this amazingly unstable substance, I was struck by its heretofore unmentioned potential as a weapon.

Imagine a high explosive anyone can make and which is harmless while moist but devastating when dry. Say you put a moist piece about the size of a grain of rice into a pipe bomb three fourths full of powder and then screw on the cap. When its moisture diffuses throughout the pipe, in about an hour, it is dry and any vibration will cause it to explode, thereby igniting the powder. Crushed into a paste, a dollop about the size of a bean on a stick of dynamite, once dry will explode the dynamite at the slightest vibration. Such a pipe bomb or stick of dynamite under the car seat of an enemy would have him out of the way an hour down the road. I'm sure you can think of many other ways to use it.

To make it, all you need is iodine crystals and strong ammonia. You can get both from most pharmacies located near hospitals. I would advise against asking for both at the same place.

If your pharmacist doesn't stock iodine crystals he can order them for you at about $12.00 for four ounces. You might tell him you are thinking of making up some first aid kits and want to make your own tincture of iodine. Four ounces is enough to last you a lifetime.

The strong ammonia can be gotten under the pretense of being a butterfly and moth collector. Ammonia in bottles with some cotton on the bottom kills butterflies quickly. The store ammonia is weaker and the soap sticks to the scales so strong ammonia is an absolute necessity.

But if you don't want to bother your pharmacist you can distill your own from store ammonia in the still described further on. Two 28 ounce bottles will provide 14 ounces of strong ammonia, free from the soap and gunk in all household cleaning ammonias.

Anyway, to make ANTI, just drop iodine crystals into ten times their volume of strong ammonia. A few grains will prove the process. After about ten minutes soaking, swirl and pour the iodine crystals into a coffee filter. Then remove the filter from its holder and scrape up the crystals and/or paste with a knife or spatula. Crystals are best for strewing around for people to step or sit on, causing coronaries. Paste is best for spreading on things and also for stability in the rate of drying. A small pile of treated crystals drying would set each other off as they settled. The paste, however, will dry uniformly and will not go off because of its own weight.

When you have put the ANTI on a board or some other surface you don't care about, use the knife or spatula to separate it into tiny bits. After an hour's drying just slightly touch one of the particles with a feather or anything else and you'll get a surprisingly loud explosion, which will most likely set off the rest if the particles are close together.

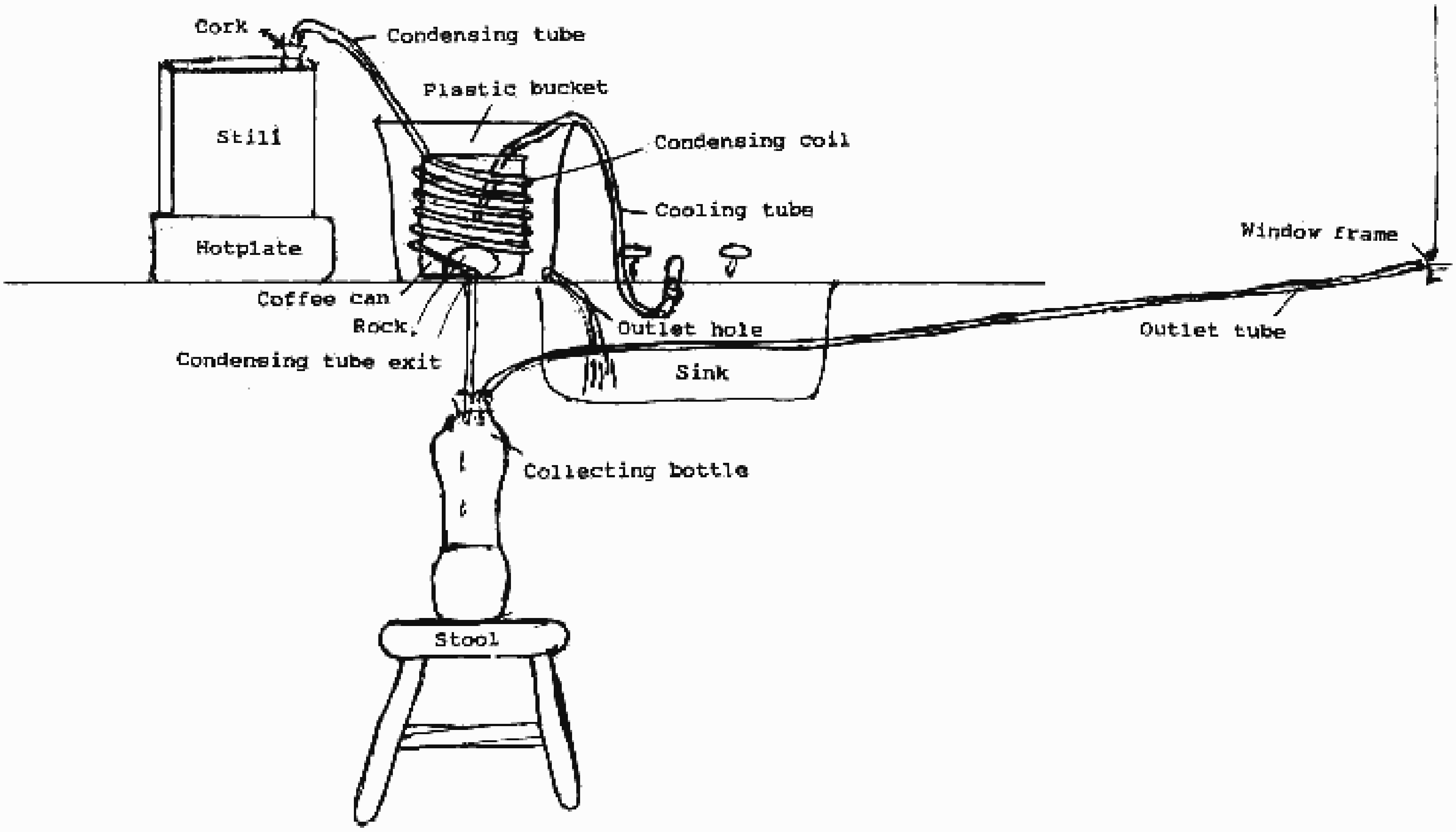
ANTI can be made in a relatively large batch and carried safely. A good way is to cut about a square inch from the corner of a plastic baggy. Put the ANTI in the bottom corner and roll it up. Then wrap it in a wet cloth and roll that up and put it in a whole baggy and roll that up too. The ANTI could stay that way for months and yet be ready for use at any time.

RATAWAY - SIMPLE MINEFIELD GUARANTEED TO RID AREA OF RATS

When a rat eats of poisoned bait, if sickness follows fast enough for him to make the connection, he can somehow communicate to his fellow rats that that food is bad. ANTI has been used to clear an area of rats. The iodine crystals are finely ground so the ANTI is a paste. The paste is dappled around food, near rat holes, along the floor by basement walls and wherever rats are known to run. As the rat sets off the ANTI, either by stepping on it or touching it with a whisker, he will be terrified and will communicate this terror to the other rats. In a couple of days they will all have left. Repeat minings every few weeks will keep any area free of rats.

THE STILL

If you buy a still from a health food store it will cost you about $200.00. But you can make one yourself out of odds and ends and just plain junk for about $7.00 and it will work as well as the expensive one. Also, all its parts can be bought from your local supermarket and hardware store.



All you need is a one-gallon gas or cooking oil can as the still, itself. The cork for the can is available from any hardware store. Then you will need a roll of plastic electrical tape, an **11** quart plastic bucket, picture hanging wire, a three-pound coffee can, a roll of three-quarter inch paper masking tape and about 20 feet of 3/8" outside diameter plastic tubing from the hardware store and some childs' modelling clay.

First, drill a 3/8" hole through the cork. Then drill two 3/8" holes in the side of the bucket at the bottom and a quarter of the distance around from each other. Through one of these holes will run the condenser coil tubing and the other will allow the excess water to squirt into the sink.

Next, take the coffee can and start the masking tape at the top and make five winds evenly down to the bottom. That will leave about an inch of uncovered can between the winds of masking tape. Now you will have the path on which to attach the condensing coil so it winds down evenly so the distillate will flow freely into the collecting container under the tubing coming from the bucket. Then take the smallest drill bit you can buy from the hardware store and drill holes through the masking tape and the can. Start drilling at the top and drill a hole every six inches until you reach the very bottom.

Then cut several three inch lengths of picture hanging wire. Start the tubing about 18 inches from one end, bend a piece of wire over it and put the two ends of the wire into the top hole. Pull the wire ends all the way in and bend them back along the inside of the can. Do the same thing six inches further on and repeat until you have the condenser coil fixed all the way around the can five winds to the bottom.

About three inches from the bottom of the can, wind plastic electrical tape around the condenser tubing maybe four of five turns. Just back toward the can, wind another section of tape maybe eight or nine turns. then begin winding more tape from the thicker part to about an inch beyond the thinner part.

Next, place the condenser coil can in the bucket and push the tubing through the hole in the bucket's side. Pull it through until the taped part clogs the hole. When the bucket is full of water, pull the taped part further until no water leaks out around the tubing.

Now set your hotplate near the kitchen sink with the plastic bucket beside it with the water vent hole just over the sink. Stick the top end of the tubing just through the cork and press modelling clay around it to stop any fumes or steam from leaking out around the tube.

Now pour two 28 ounce bottles of household ammonia into the can and put the cork in tightly. Turn on the hotplate just past MEDIUM and wait until you smell fumes coming from the end of the tube hanging down into the collecting bottle on a stool by the sink and directly under the bucket. Before filling the bucket with water put a rock or other weight inside the can lest the air in the condensing coil tilt it once the can and bucket are filled with water.

Cut off about two feet of the bottom of the tubing and stick an end into the fawcet. Wrap a plastic baggy around the fawcet and the tube. Secure the tube by wrapping plastic tape around the fawcet, the baggy and a bit of the tubing. This will keep the water inside the tubing.

Since you will be dealing with ammonia you won't want to stink up the house. Take your 3/8" drill and make a hole through the frame of the nearest window and stick an end of the spare tubing through it. This will lead any stray fumes outside and when not in use, the hole can be covered with a small bit of tape and should not be noticeable.

When you smell the fumes coming from the end of the condenser tube fill the bucket with cold water and turn on the water fawcet just enough to compensate for the amount of water spurting out from the bottom of the bucket into the sink. You must do this to keep cool water in the bucket, otherwise the water in the bucket would heat up and would not condense the steam and ammonia gas coming from the still.

When the action has started make sure the condensing tube end is in the collecting bottle along with an end of the tubing leading outside. Press modelling clay around the two tubes so no fumes escape into the kitchen. Now you are ready to distil the ammonia.

By the time you've finished setting up the ammonia should be about ready to boil. Actually, ammonia is a gas which has combined with the water. The water has to boil so it will come over with the ammonia. Otherwise, the ammonia will just leave the water and pass through the tube to the outside. But with the water at a good boil, the ammonia will come over with it. When the collecting bottle is half full, stop the process. Take a cautious sniff of the open collecting bottle and you'll notice it is much stronger than the original. Smell what is left in the still and you will see there is hardly any ammonia smell at all. So you have not only condensed the ammonia into one quarter of the original amount of water but you've left the soap and other gunk behind. Wasn't that fun?

You can use the same still to take alcohol from wine, which then makes it brandy. You can also pour in rubbing alcohol, which is 30% water and take out nearly pure alcohol. When working with alcohol you must realize that it boils at 173 degrees F instead of 212 as does water. So when you want alcohol you use a kitchen thermometer stuck in the mouth of the still. When the thermometer registers 173 degrees or slightly higher, put the cork and its tube in the still and turn the heat down slightly so the temperature doesn't rise.

The alcohol should come over in a pretty steady flow if you have the heat adjusted to the point where it is above 173 but below 212. When the flow just about stops you will get nothing further but drops of water, which you don't want so stop the process.

You can make this still in a few hours and it will last indefinitely with minor repairs. Once you've learned to use and adjust it properly to fill your needs, it will be a handy and reliable tool.

FIRE GRENADES

Molotov coctails have a way of being bulky and hard to throw far or accurately. The use of lightbulbs as fire grenades gives you longer range and accuracy. They are simple to prepare and more sturdy than you might realize. Their size also permits one to carry such a weapon in a pants pocket if concealability is a consideration. Their availability is universal ond one who saves his standard light bulbs after they've burned out will have a good supply in a short time.

Using a standard light bulb, pour in four ounces of gasoline. Use no more, since, if the bulb is full, it may not work. Gasoline does not burn; it is only the fumes that burn. Therefore, if you fill the bulb completely, the liquid is apt to put out the flaming cotton fuse. But if you allow for an air space, fumes will be released on impact and the gasoline will work as it is supposed to.

For more sticking effect, you can mix the gasoline with half roofing tar or crank-case oil. Chain-Saw oil increases the burning rate. But, for all intents and purposes, plain gasoline will serve.

To make the fire grenade, first treat the bulb as if you were making a chemistry flask, page 7. Then fill it with the combustible liquid and stuff a piece of cotton into the hole tight enough so it won't fall out but loose enough for the liquid to soak the top part and act as a wick. Tilt the bulb so the wick is saturated and it's ready to light.

If you just have one target, a good carrier is a Campbell Soup can. Put a layer of paper towling in the bottom of the can to act as a cushion. This will enable you to carry the greande in a pants or jacket pocket without fear of its breaking.

AMMONIUM NITRATE

Some Militants who don't have much dynamite use ammonium nitrate. This can be bought by anyone at $3.75 for an 80 pound bag. It is a fertilizer.

Ammonium nitrate explodes at rates up to 14,000 feet per second. It is roughly compared to dynamite having 60% nitro.

The fertilizer grade Militants use is mixed with motor oil at the ratio of one pint of oil to 8½ pounds of ammonium nitrate. This has to be detonated with a stick of gelatin dynamite.

Purified ammonium nitrate can be detonated with a number six dynamite cap. The pure stuff can be bought at chemical supply houses or the fertilizer grade can be purified with distilled wood alcohol.

Put several pounds of fertilizer grade ammonium nitrate in a pan. Pour in enough wood alcohol (methanol) to cover the fertilizer. Then stir it until a lot of it has dissolved. Next, let it set a few minutes to allow the impurities to settle to the bottom along with the undissolved ammonium nitrate.

Another pan is set on some pieces of dry ice for the next step. Dry ice can be found in the business section of the phone book under "Dry Ice." Locker companies will sell it to anyone, cheaply and in small amounts.

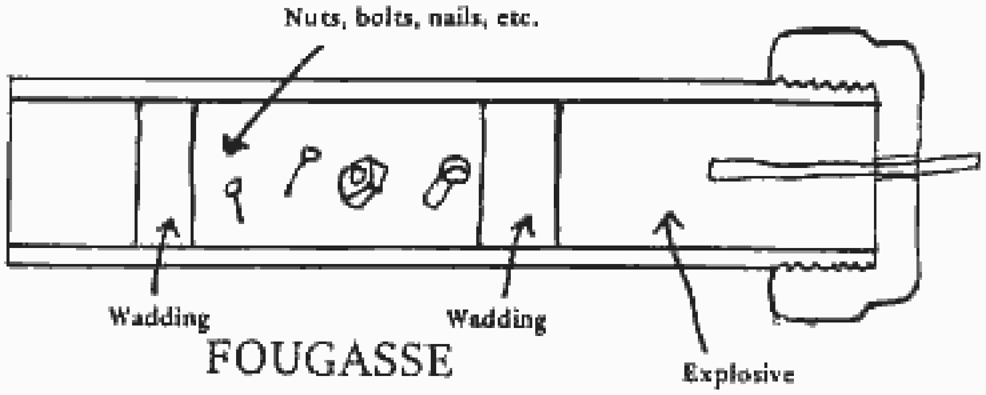
The dissolved ammonium nitrate is poured into the cold pan. This is done carefully so as to leave the impurities and undissolved ammonium nitrate behind.

The dry ice causes the purified ammonium nitrate to precipitate out of the solution in crystals. When no more crystals are formed they are removed from the alcohol.

The alcohol is then poured back into the other pan and stirred to dissolve any ammonium nitrate left undissolved. After setting a few minutes the solution is again poured off the dregs and the dregs are thrown away. When the last batch of crystals is removed, the alcohol can be stored and reused.

The dry ice is simply frozen carbon dioxide and its fumes are harmless unless they are enough to replace the air. Don't handle the dry ice with your bare hands as its cold will cause blisters.

In order for pure ammonium nitrate to be detonated by a dynamite cap, it must be very dry. Spread it out under a heat lamp or in the sun. When completely dry, store it in tightly closed plastic bags.



FOUGASSE

This is like a big shotgun or the old-fashioned blunderbus. It is simply a pipe with a cap on one end drilled for a fuse. It is stuck in a tree or laid down. If you hold it you'll be kicked a mile.

When the fuse is put in, a couple of inches of gunpowder is added. Then some cotton or paper wadding is put in and pressed down gently but firmly.

Next, some nuts and bolts are poured in and some more wadding is tamped in to hold them in place.

The fougasse doesn't have much of a range but it is hell on a crowd or down an alley.

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EXPLOSIVES

INTRODUCTION TO PRIMARY EXPLOSIVES

Explosives are substances which undergo a rapid chemical change to produce large amounts of gases. Since the reaction is exothermic, that is, a reaction which releases heat, the gases are expanded, producing a still more forceful explosion. Explosives are classified as either low explosives or propellants, or high explosives, the difference being in the way they function. Low explosives burn and are set off with a fuse. The explosion results from the bursting of the casing in which they are held.

High explosives detonate, which is a much more rapid chemical change than burning. Although detonation is usually accompanied by a flame, it is not a burning process and some high explosives do not contain oxygen. Under high explosives are two subclasses: primary or initiating, and secondary. Secondary high explosives are set off by shock, this generally being provided by a blasting cap. They are generally much less sensitive and more powerful than primary explosives and, because of these properties, are used as the main blasting charge in most industrial blasting operations.

Primary high explosives will turn an ignition into a detonation, and some primary explosives are used in blasting caps to set off secondary high explosives, hence the name initiating. Primary explosives are much more sensitive than secondary explosives and much more care should be used when working with them. Included in this booklet are the preparations of mercury fulminate, lead azide, and several priming mixtures; these explosives were chosen because they are the most widely used in blasting caps.

Some of the compounds and some of the chemicals used in their preparations are very dangerous. We suggest that you always use the proper safety precautions when working with any chemicals. This booklet is published strictly for educational purposes. Any person making the compounds using the procedures in this booklet should keep in mind that THESE CHEMICALS AND COMPOUNDS ARE DANGEROUS, and the author cannot be held responsible for accidents arising from the preparation of these compounds. Any inexperienced person should seek the guidance of a chemistry teacher or other qualified person before attempting the preparation of these compounds.

MERCURY FULMINATE

In many states there are laws pertaining to the making, storage, and use of explosives. Before attempting to make, use, or store any explosives or dangerous chemicals, you should obtain permission from your state, local, and any other authorities which may have control over them.

Mercury fulminate was the first primary explosive to be used in blasting caps and is still used in fuse-type blasting caps. It has a chemical formula of $Hg(OCN)_2$. It is a fairly sensitive primer and is easily detonated by flame or shock. Its preparation requires highly purified materials and in our laboratory tests only reagent grade materials were used. It is prepared by adding metalic mercury to nitric acid, in which it dissolves, then reacting the acid solution with ethyl alcohol. All the reactions are exothermic but, in quantities as small as the one to be described, no cooling is necessary. For this reason, mercury fulminate should never be prepared in a larger quantity than the one in the preparation.

Mercury fulminate is a white to grey crystalline solid, which is only slightly soluable in water, and is nonhydroscopic. It explodes at 150-160° (all temperatures in this booklet are given in the centigrade scale). It has a detonating rate of 4,000 meters per second. Mercury fulminate can become dead pressed; that is, compacted to a density at which it can no longer be detonated by flame. Mercury fulminate should always be stored in water to avoid any decompositions. It should also be kept out of the light and kept cool.

Preparation of Mercury Fulminate: Five grams of mercury is added to 55 grams of concentrated nitric acid (70% concentrated specific gravity 1.42) in a 250-ml. beaker. The mercury will usually begin to dissolve, giving off red fumes. This preparation should be carried out out-doors or under a hood since the fumes are nitrogen dioxide and are deadly poisonous. If the mercury does not dissolve or if it does not completely dissolve, the beaker should be heated gently. After it is dissolved, transfer the acid solution to a 1,000-ml. beaker containing 50 grams of ethyl alcohol. A reaction will take place evolving white fumes. In about 5 minutes the reaction will stop and the mercury fulminate is filtered out. It should be washed with distilled water several times to remove the acid. It is then set out to dry to be used or placed under water and stored.

LEAD AZIDE

Lead azide is a somewhat less sensitive initiator than mercury fulminate and is a much more effective initiator than that explosive. Its chemical formula is Pb $(N_3)_2$. It is made by reacting solutions of lead acetate and sodium azide together, and the reaction is endothermic.

Lead azide is a white crystalline solid, practically insoluable in water, and nonhydroscopic. It detonates at 383°; and, because of this higher detonating temperature, lead azide is not always detonated by the end spit of a safety fuse. In storing, lead azide should be kept cool and away from heat and light.

Preparation of Lead Azide: Six grams of lead acetate is dissolved in 300-ml. of water at 70° in a 400-ml. beaker and is poured into a 600-ml. beaker containing 10 grams of sodium azide dissolved in 200-ml. of water at 50° and stirred. A white solid will immediately form which is filtered and allowed to dry completely. Lead azide should not be stored under water because of its crystallizing properties.

PRIMING MIXTURES

In modern blasting caps, mercury fulminate is mixed with potassium chlorate. This makes the explosive cheaper as well as more powerful. The two most commonly used formulas are 80/20 and 90/10 mixtures of mercury fulminate and potassium chlorate, respectively. The 80/20 mixture has almost completely replaced the others. Potassium perchlorate may be used instead of potassium chlorate in an 85/15 mixture.

One of the main disadvantages of using mercury fulminate as an initiator is its tendency to become dead pressed. Mixing lead azide and mercury fulminate together in a 3 to 1 ratio, respectively, eliminates the possibility of it becoming dead pressed and also insures that the lead azide will detonate from the end spit of a safety fuse. This mixture should never be placed in a copper tubed blasting cap.

THE PREPARATION OF BLASTING CAPS

Blasting caps for the purpose of initiating high explosives, consist of a copper or aluminum tube which is closed at one end and filled with a certain amount of primary explosive and sometimes a booster explosive. The other end is left open to receive the safety fuse which is placed in and crimpted prior to use or, in the case of an electric blasting cap, an ignitor assembly consisting of an ignitor wire which glows red hot when a current in run through it, an ignitor compound to help ignite the primary explosive, a rubber cap which is crimped into place to protect the cap from water, and leg wires which are connected to the main firing line. The tube usually has an inside diameter of 3/16 inch, and the length is determined by the amount of explosive which will be contained in it. Whether the tube is copper or aluminum depends upon the primary explosive to be used. Lead azide should never be used in a blasting cap that has a copper tube for the container. This is because of the formation of copper azide which is a very sensitive explosive. The amount of primary explosive used depends upon the explosive to be detonated. Blasting caps for detonating dynamite contain .5 grams of the 80-20 mixture of mercury fulminate and potassium chlorate. Electric caps are rated by the numbers 6 and 8. A number 6 cap contains .2 grams of the 80/20 mixture and .4 grams of a booster explosive known as pentaerythritoltetranitrate (abbreviated PETN). The purpose of using a booster explosive is to reduce the amount of primary explosive needed in a cap, thereby reducing the dangers involved in handling the caps since it would be less likely to be set off from accidental shock. Booster explosives are secondary class high explosives but are more sensitive than the ones used in the main blasting charge. A number 8 cap is twice as powerful as a number 6 and, of course, is used for setting off less sensitive explosives such as starch nitrate. It contains .2 grams of the 80/20 mixture and .8 grams of pentaerythritoltetranitrate. This cap has approximately the same power as 2 grams of the 80/20 mercury fulminate-potassium chlorate mixture. It might be noted that different explosive companies will use different primary and booster explosives, such as diazodinitrophenol (DDNP), manitol hexanitrate, trinitrophenolmethylnitramine (tetryl) and cyclotrimethylenenitramine (cyclonite) to name a few. The explosives mentioned above are most suited to amateur use and are approximately the same strength as the commercial blasting caps.

A suitable blasting cap for detonating dynamite, which is easily prepared from ordinary materials, consists of an empty 22 shell (the long rifle size) which is filled with the 80/20 mixture. The shell will hold about .4 grams of this mixture which will detonate most dynamites. Fuse for this cap can be easily made by filling an ordinary plastic straw with a 60/40 mixture of potassium nitrate and brown sugar, respectively. Other mixtures, such as 70/30 and 75/25, may also be used. The mixture burns very slowly, but all fuses to be used in connection with explosives should be tested by burning a short length before using. The straw will fit over the shell and masking tape should be wound a the way up the straw. The tape will keep the explosive fr being set on fire by the fuse. Usually about two thicknes of masking tape will prevent this. For larger caps, coppe or aluminum tubing can be used. As stated before, the tub should be 3/16-inch inside diameter and about 1/4-inch out diameter. It is necessary to experiment to get the right length for the particular amount of primary explosive to b used. Always allow at least 1/2-inch to receive the safet fuse or, if you wish to make your own fuse by the method m tioned above, this distance may be filled with the fuse po der. This will also prevent the primary explosive from falling out until the cap is used. To seal the other end the cap, the best method is to press wax in it. It is advisable never to crimp this end or any other part of the cap except for receiving the safety fuse (if used). For t type of cap another fuse may also be used which will fit in the cap. To make it, a small piece of cotton string is coa with a wet mixture of potassium nitrate 75%, charcoal dust sulfur 9%, and dextrin 2%, by running it through the mixtur This is allowed to dry thoroughly. It is then covered with two thicknesses of masking tape, and the burning rate is tested as before. This is a much faster burning fuse than the one used before and also produces less smoke. To secur it to the blasting cap, wrap a small piece of tape around both. It is very important to make sure the fuse is seated snugly against the primary explosive.

PRIMING EXPLOSIVES WITH BLASTING CAPS

There are three general methods of attaching the blasting cap into the explosive cartridge and any of them are suitable, provided that the cap is securely held in place inside the cartridge so that it cannot be accidentally pull from it. In wet conditions, the attachment must be waterproof.

In side priming, a hole is punched in the side of the cartridge and into the explosive so that the cap will be in the center of it. The business end of the cap should be always pointing in the direction of the rest of the cartridges, if any. The business end is the end containing the explosive or opposite the end that receives the fuse. The cap may be held in place by wrapping over the hole with electrician's tape.

Bottom end priming is probably the most satisfactory for getting the most effeciency out of the explosive since it confines all the explosion gasses until the entire charg has detonated. A hole should be placed in the center of th end of the cartridge to a depth that will confine the explo sion of the cap into the explosive and will not permit it to merely blow the end off the cartridge. Tape should be placed around the bend in the fuse to hold the cap in the explosive. Since the fuse must be bent sharply back around the cartridge, the plastic straw type fuse cannot be used and care should be taken when using any type of fuse that it is not bent so sharply that it breaks the powder core.

Top end priming is usually the easiest when blasting with fuse-type blasting caps. As in priming with the bottom method, a hole is placed in the center of the end of the cartridge to the proper depth and the cap is placed in it. The fuse is then brought to one side and tied with string or taped across the bottom of the cartridge.

The cheapness and availability of ammonium nitrate has brought into use many cap insensitive explosives, such as ammonium nitrate-fuel oil mixtures. These explosives are too insensitive to be set off by even a number 8 blasting cap. In order to detonate them a booster charge is needed. This consists of a highly brisant cap sensitive explosive such as blasting gelatin or gelatin dynamite. These explosives are placed in the bore hole next to the other explosives and the blasting caps are placed in them.

INTRODUCTION TO HIGH EXPLOSIVES

Explosives are substances which undergo a rapid chemical change to produce large amounts of gasses. Since the reaction is an exothermic one, a reaction which releases heat, the gasses are expanded, producing a still more forceful explosion. Explosives are classified as either low explosives or propellants and high explosives, the difference being in the way they function. Low explosives burn and are set off with a fuse. The explosion results from the bursting of the casing in which they are held.

High explosives detonate, which is a much more rapid chemical change than burning. Although detonation is usually accompanied by a flame, it is not a burning process and a few high explosives do not contain oxygen. Under high explosives are two sub classes: primary, or initiating, and secondary. Primary explosives will turn into a detonation and some primary explosives are used in blasting caps to set off secondary high explosives (hence the name initiating). Examples of these are lead azide and mercury fulminate. Secondary high explosives are set off by shock, this generally being provided by a blasting cap. Nitric esters and the other high explosives discussed in this booklet are secondary high explosives. If you wish to make blasting caps to set them off, see our booklet "The Preparation of Primary Explosives and Blasting Caps" which gives their complete preparations. It might be noted that, although secondary high explosives are generally set off by shock if ignited in sufficiently large quantities and after burning for some time, they may eventually build up enough heat that the explosive will be raised to its detonating temperature and, of course, go off.

High explosives, because of their detonating rates ranging from under 2,000 to 8,100 meters per second, are very brisant. Brisance is defined as the shattering quality in an explosive. This quality is wanted when the explosive is being used in blasting hard rock or penetrating armor. The more brisant explosives are pure nitrated organic materials such as cyclonite, trinitrotoluene (TNT), or blasting gelatin. The less brisant ones are explosives such as ammonium nitrate or mixtures of nitrated and non-explosive ingredients such as dynamites. These explosives are used in blasting sand or when a great deal of push-type power is wanted. Gelatin dynamites, the most brisant in this group, are brisant enough to be used in most hard rock or underwater applications. The velocity of these explosives can be varied by the granual size, coarser dynamites being less brisant.

When choosing the right explosive for a particular job, the following properties should be taken into consideration: brisance and heat, necessity of resistance to moisture, sensitivity to impact and heat, thermal and other decompositions. Brisance, as discussed before, would be wanted in hard rock, underwater, and in most military applications, or whenever a shattering effect is desired. An explosive with low brisance would be used in sand or soft rock or in mining operations when large chunks of coal are wanted. Heat in mining operations is not wanted since it could ignite explosive gasses in the mine. Ammonium nitrate dynamites are commonly used or dynamites containing large amounts of a cooling ingredient such as sodium chloride. Such explosives are known as permissables. High heat and high brisance seem to run together and generally when heat producing ingredients, such as aluminum dust, are added, the brisance is increased. Resistance to moisture would be needed in extremely humid regions or under water. Hydroscopic explosives (a hydroscopic substance is one that absorbs moisture from the air), such as ammonium nitrate, could not be used unless protected. Thermal decomposition must be taken into account when using or storing the explosive at high temperatures. Glycerol trinitrate is very sensitive at high temperatures, especially if there is any acid left in it. Most nitrated organic explosives give off fumes when decomposing. When this is noticed, the explosive should be destroyed as it has become extremely sensitive. Sensitivity to impact must be taken into account when the explosive will be subjected to extreme shock as in the case of a shell filler. Obviously dynamites could not be used and instead trinitrotoluene or ammonium picrate may be used.

The first explosives to be discussed will be nitrated organic compounds. Some of these compounds and some of the chemicals used in their preparations are very dangerous. We suggest that you always use the proper safety precautions when working with any chemicals. This booklet is published strictly for educational purposes. Any person making the compounds using the procedures in this booklet should keep in mind that THESE CHEMICALS AND COMPOUNDS ARE DANGEROUS, and the author cannot be held responsible for accidents arising from the preparation of these compounds. Any inexperienced person should seek the guidance of a chemistry teacher or other qualified person before attempting the preparation of these compounds. In many states there are laws pertaining to the making, storage, and use of explosives. Before attempting to make, use, or store any explosives or dangerous chemicals, you should obtain permission from your state, local, and any other authorities which may have control over them.

NOTES TO PREPARATIONS

All the nitric esters in this booklet are prepared by adding the organic substance to mixed nitric and sulfuric acids, sometimes called nitrating acid. The acids and organics used in our tests were of reagent grade quality, and we have made no tests to determine how well any other grades would work. Both the acids must be concentrated. The nitric acid should be approximately 69-70% with a specific gravity of 1.42. The sulfuric acid should be approximately 95-98% concentrated with a specific gravity of 1.84. The mixing of the acids and the addition of the organic substances are both exothermic reactions and a cooling system is needed to keep the mixtures from building up too much heat in the course of mixing. The following system may be used in each of the preparations provided the quantity of chemicals is no larger than that described in the preparation; larger quantities will require larger cooling systems. A foil pie pan, about nine inches in diameter and one and one-half inches deep is filled with ice and the space between the ice particles is filled with water. Salt may be placed on the ice, if desired, for greater cooling. The beaker is placed in a hole in the middle of the pan.

When the liquid nitrates are poured into water after their treatment with the acids, the acids should dissolve in the water, the nitrate will collect as a white or clear insoluable liquid at the bottom of the beaker. For filtering glycerol trinitrate, all that is required is a piece of cloth,

GLYCEROL TRINITRATE

Glycerol trinitrate is one of the most important industrial explosives because of its use in dynamites and double base powder, the propellant used in guns. Although it is commonly called nitroglycerin, it is, of course an ester of nitric acid, and not a nitro compound. Since this is a scientific publication, the compounds will be referred to by their correct chemical names. Glycerol trinitrate has a specific gravity of 1.60 at 15°. Its chemical formula is $C_3H_5(ONO_2)_3$. Its structural formula is:

$$\begin{matrix} CH_2\text{-}ONO_2 \\ CH\text{-}ONO_2 \\ CH_2\text{-}ONO_2 \end{matrix}$$

The equation for its decomposition is:

$$4C_3H_5(ONO_2)_3 - 6N_2\text{-}12CO_2\text{-}10H_2O\text{-}O_2$$

As you can see by the equation, glycerol trinitrate has more than enough oxygen to completely oxidize all of its oxidizable elements. This is called a positive oxygen balance, which accounts for the fact that glycerol trinitrate is one of the most powerful explosives known. It has a detonating rate of approximately 7,700 meters per second.

ETHYLENE GLYCOL DINITRATE

Ethylene glycol dinitrate is another important nitric ester. It is used in combination with glycerol trinitrate in dynamites to reduce the freezing point of the latter compound, usually in about an 80-20 mixture respectively. This mixture may be used in place of glycerol trinitrate in the dynamite formulas given later. Ethylene glycol dinitrate is commonly abbreviated EGDN and it is often referred to as nitroglycol or glycol dinitrate, both in error. Ethylene glycol dinitrate has a specific gravity of 1.496 at 15°. Its chemical formula is $C_2H_4(ONO_2)_2$. Its structural formula is:

$$\begin{matrix} CH_2\text{-}ONO_2 \\ CH_2\text{-}ONO_2 \end{matrix}$$

The equation for its decomposition is:

$$C_2H_4(ONO_2)_2\text{-}2CO_2\text{-}2H_2O\text{-}N_2$$

As you can see by the equation, ethylene glycol dinitrate has a neutral oxygen balance; that is, it contains the exact amount of oxygen needed to oxidize its carbon and hydrogen. Ethylene glycol dinitrate, as does glycerol trinitrate, gives headaches to persons who breathe its vapors or absorb it through the skin. Headaches caused by ethylene glycol dinitrate are acquired faster and are more violent, but shorter in duration than those caused by glycerol trinitrate. It should be noted that ethylene glycol dinitrate is much more poisonous than glycerol trinitrate, and gloves should always be worn when working with it.

CELLULOSE NITRATE

Cellulose nitrate is another very important nitric ester. It is used in double and single base powders and in blasting gelatin and gelatin dynamites. Since the correct formula for cellulose is not known, it is not known how many nitrate radicals a single molecule of cellulose nitrate contains, so the name of cellulose nitrate is not chemically correct; however, since the correct name for it is not known, cellulose nitrate is generally accepted. It is sometimes erronously called nitrocellulose. Cellulose nitrate is rated by the per cent of nitrogen it contains, 14.14 being the highest possible nitrogen content for cellulose nitrate, theoretically.

In the preparation of cellulose nitrate, not too much heat is liberated when the cellulose is added to the acids; and, since the quantity of cellulose in this preparation is small, it may be added all at once.

Preparation of Cellulose Nitrate: Thirty grams of sulfuric acid and 15 grams of nitric acid, which has been diluted with 1 gram of distilled water, are weighed in a 250-ml. beaker. It is now placed in the cooling system and cooled to 25°. One gram of cellulose (cotton) is now added to the acids. This is allowed to set for one hour. The cellulose nitrate and acid are poured into a beaker containing 600-ml. of water. This is stirred for a short while, then filtered. The cellulose nitrate is then heated at 80° for 4 minutes in 600-ml. of water. If a pH test shows acidity, the process is repeated; if not, the excess water is pressed out and the cellulose nitrate is spread out to dry completely. It is now ready to be used.

STARCH NITRATE

Starch nitrate was used in the first world war in hand grenades because of a shortage of toluene which is necessary to produce trinitrotoluene. Starch nitrate may be detonated by a number 8 blasting cap and as is obvious, starch nitrate is rather insensitive to detonation in comparison with the other explosives in this booklet. Starch nitrate is commonly, but erronously, called nitrostarch. It is not a devinate single compound but a mixture of starch nitrates of different degrees of nitration. Starch nitrate is rated, as is cellulose nitrate, by nitrogen content; 12.5 being a good nitrogen content for starch nitrate. To make a larger quantity of the compound is easily done since the addition of starch does not cause the temperature to rise much.

Preparation of Starch Nitrate: Forty-eight grams of sulfuric acid and 25 grams of nitric acid are mixed in a 250-ml. beaker and placed in the cooling system. After the acid mixture has reached a temperature of 20° or lower, 10 grams of starch is slowly added, not allowing the temperature to rise above 25°. After all the starch has been added, the mixture is allowed to set for 30 minutes. The mixture is now poured into a beaker containing 600-ml. of cold water, and stirred for several minutes. The solution is now filtered and the starch nitrate is placed in the acid neutralization solution and left for 5 minutes. After filtering, the compound is given a pH test and either treated again for acid or placed in 600-ml. of water at 40-60° for removal of alkali. It is very important that the compound is ridded of the last traces of acid for it to perform properly. The compound is now spread out to dry completely, after which time it is ready to be used.

STRAIGHT DYNAMITES

Group I

Glycerol Trinitrate	20	25	30	40	45	50	60	75
Sodium Nitrate	70	50	62	45	5	30	20	
Wood Meal	10	25	8	5		20	20	
Starch					50			
Kieselguhr								25

Group II

Glycerol Trinitrate	20	23	25	30	40	50	56	60
Potassium Nitrate	70	41	47	61	43	23	20	15
Wood Meal	10	36	8	9	17	27	4	25
Aluminum dust							20	
Sodium Chloride			20					

DYNAMITES

Dynamite was the first high explosive used for blasting and is still the main high explosive for commercial purposes. The first dynamite, made by Alfred B. Nobel, was a combination of glycerol trinitrate and keiselguhr, a variety of diatomascious earth, as a desensitizer. This composition is shown in Group I. This dynamite, called guhr dynamite, has what is known as an inert base. That is, the absorbent, keiselguhr, does not chemically change when the dynamite is detonated, which means that the dynamite is not too powerful. The other dynamites contain active bases which consist of wood meal as an absorbent, fuel, and an oxidizer to oxidize it. The strength of a dynamite is rated by the total percentage of glycerol trinitrate in the dynamite. Group II contains potassium nitrate as an oxidizer, which is less hydroscopic than sodium nitrate that is used in Group I. The properties of the additives, sodium chloride and aluminum dust, as explained before, are to reduce or increase brisance and heat.

BLASTING GELATIN AND GELATIN DYNAMITES

Glycerol Trinitrate	93	92	37	47	56	56	65	75
Cellulose Nitrate	7	8	3	3	4	4	5	5
Potassium Nitrate			48	40	30		22	
Sodium Nitrate						32		16
Wood Meal			12	10	10	8	8	4

The invention of blasting gelatin led to a new series of dynamites called gelatin dynamites. Blasting gelatin, as shown by the above compositions, consists of glycerol trinitrate that has been colloided with 7-8% of cellulose nitrate. It is rated at 100% strength and is the most powerful industrial explosive in use. It is also the most brisant and most water resistant. It has a velocity of 7,800 meters per second at d. 1.63. The substitution of blasting gelatin for glycerol trinitrate in dynamites gives a series of gelatin dynamites which, like blasting gelatin, have the properties of being brisant, water proof, and powerful. Both are excellent for underwater work.

AMMONIA AND SEMI-GELATIN DYNAMITES

Glycerol Trinitrate	10	10	20	33	10	25	30	75
Cellulose Nitrate					1	1	1	5
Ammonium Nitrate	70	83	75	30	59	64	30	15
Potassium Nitrate				27			30	
Wood Meal	10	7	5	10	15	10	9	5
Sodium Nitrate	10							

The above compositions make use of ammonium nitrate for an oxidizer. It is interesting to note the added power ammonium nitrate imparts to these compositions. For example, a straight dynamite requires 60% glycerol trinitrate to have a 60% power; however, ammonia dynamites require as little as 20% to have the same power. Ammonia dynamites are very cool explosives with limited brisance which produce small volumes of obnoxious fumes upon detonation, commending their use in underground work, such as tunneling. Ammonium nitrate is very hydroscopic and must be protected from moisture. Because of its detonation properties, the best effeciency can only be obtained in large diameter casings. The ammonium nitrate version of gelatin dynamites is called semi-gelatin dynamites as shown in the last four compositions. Its brisance and water resistance are improved somewhat and, like ammonia dynamites, it produces small volumes of obnoxious fumes. They are sometimes used as a booster for setting off less sensitive ammonium nitrate explosives.

STARCH NITRATE EXPLOSIVES AND GRENITE

Starch Nitrate	23	24	25	27	95	96	97	98
Ammonium Nitrate	35	35	40	30				
Sodium Nitrate	37	32	28	40				
Charcoal dust	4	5	4	2				
Fuel Oil	1	2	2	1	3	2	2	1
Diphenolamine		2	1					
Gum Arabic					2	2	1	1

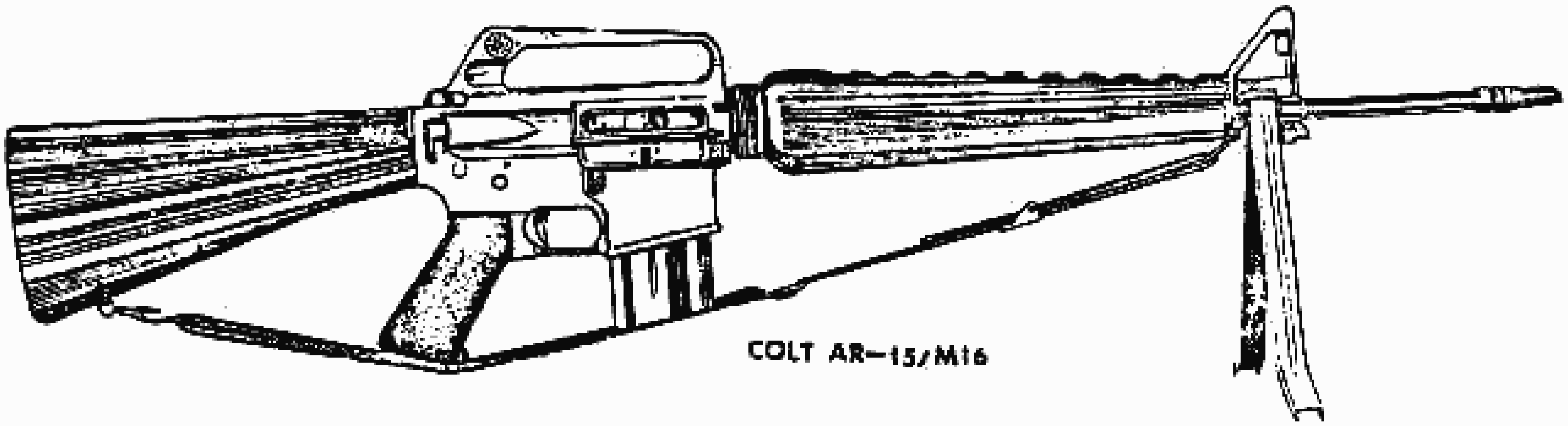
The above explosives use starch nitrate as a sensitizer and, as explained before, starch nitrate is rather insensitive to detonation; therefore, the explosives derrived from it are not. The purpose of the liquid hydrocarbon additives (fuel oil and xylene) is to protect the mixture from moisture, especially in the mixtures containing ammonium nitrate. The last four mixtures are called grenite, used in hand grenades.

FULLY AUTOMATIC WEAPONS

Fully automatic weapons are notoriously wasteful of ammo but so intriguing to gun buffs that underground gunsmiths have been publishing crude instructions for years. Since the ATF has begun cracking down on the sale of auto-conversion kits, the do-it-yourself-from-scratch techniques have gained popularity. So here are four plans I've had lying around for years and now hope some of my readers may enjoy the challenge of figuring them out. Once you've mastered the technique of converting most semi-automatics to full-auto you can make money right away by converting your best friends' guns until you get that job making license plates.

AR–15 TO M16

CONVERSION INSTRUCTIONS



COLT AR–15/M16

Tools needed:

electric drill
1/4 inch drill bit
Small pointed metal rotary file/rasp bit
1/8 inch drill bit

DIRECTIONS

Strip AR-15 rifle down to lower receiver.

Remove the following parts: hand grip (watch out for that detent and spring), safety selector, hammer, carrier, trigger & disconnector.

Take the necessary parts from the AR-15 carrier and put them into the M-16 carrier.

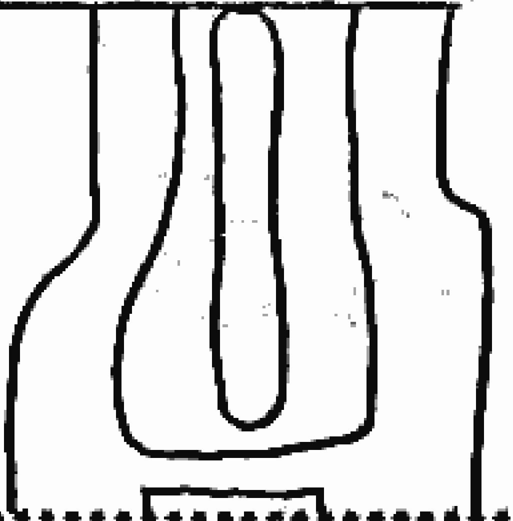
Take the electric drill and the small rotary rasp bit and grind out the area in the lower receiver housing as shown in the crudely drawn diagram below. BE CAREFUL TO GRIND ONLY ENOUGH METAL OUT TO MAKE ROOM FOR THE SEAR. It is only necessary to grind away the metal for about 1 1/4 inches back towards the buttstock.

After the above is completed, use the 1/8 inch drill bit to drill the hole in the lower receiver housing for the sear pin. Drill STRAIGHT UP from the letter "R" in the word "FIRE" and come DOWN EXACTLY 5/32 of an inch. It is very important to drill this hole in the proper place as indicated.

After this step has been completed you are ready to install the M-16 parts in your AR-15.

Install the sear with the LONGEST part pointing DOWN.

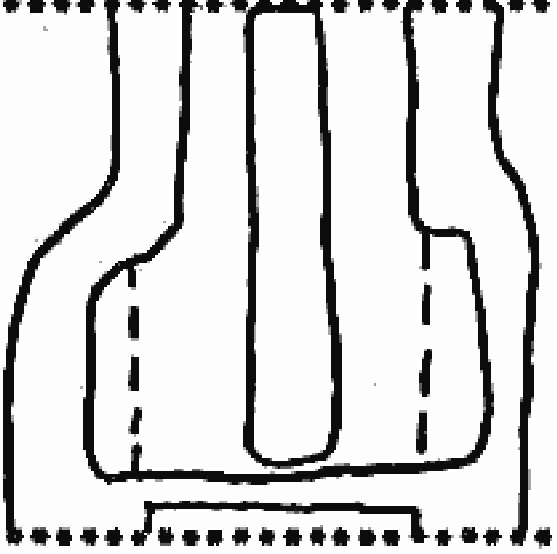
This is a top view of the inside of the lower receiver BEFORE the metal has been ground away. This MUST be done in order to make clearance for the M16 sear.



* * *

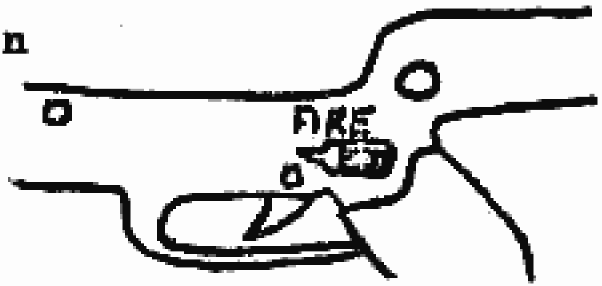
To the right is a top view of the lower receiver of your AR-15 AFTER the necessary metal has been removed. Now the correct space and clearance is provided for the M16 sear.

NOTE: dotted line represents metal that was removed by grinding.



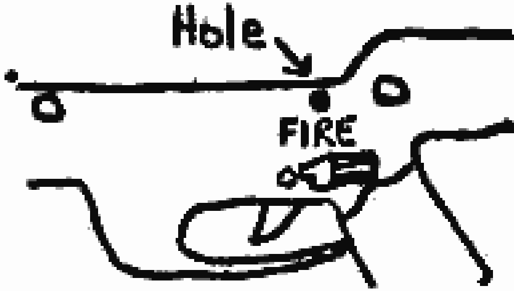
* * *

BEFORE sear pin hole has been located and drilled.



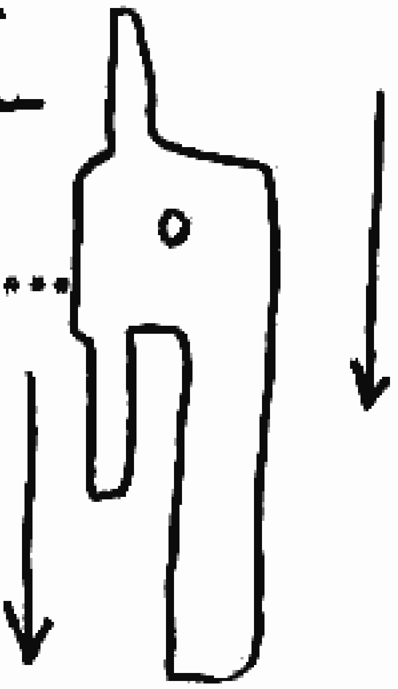
* * *

AFTER sear pin hole has been drilled.



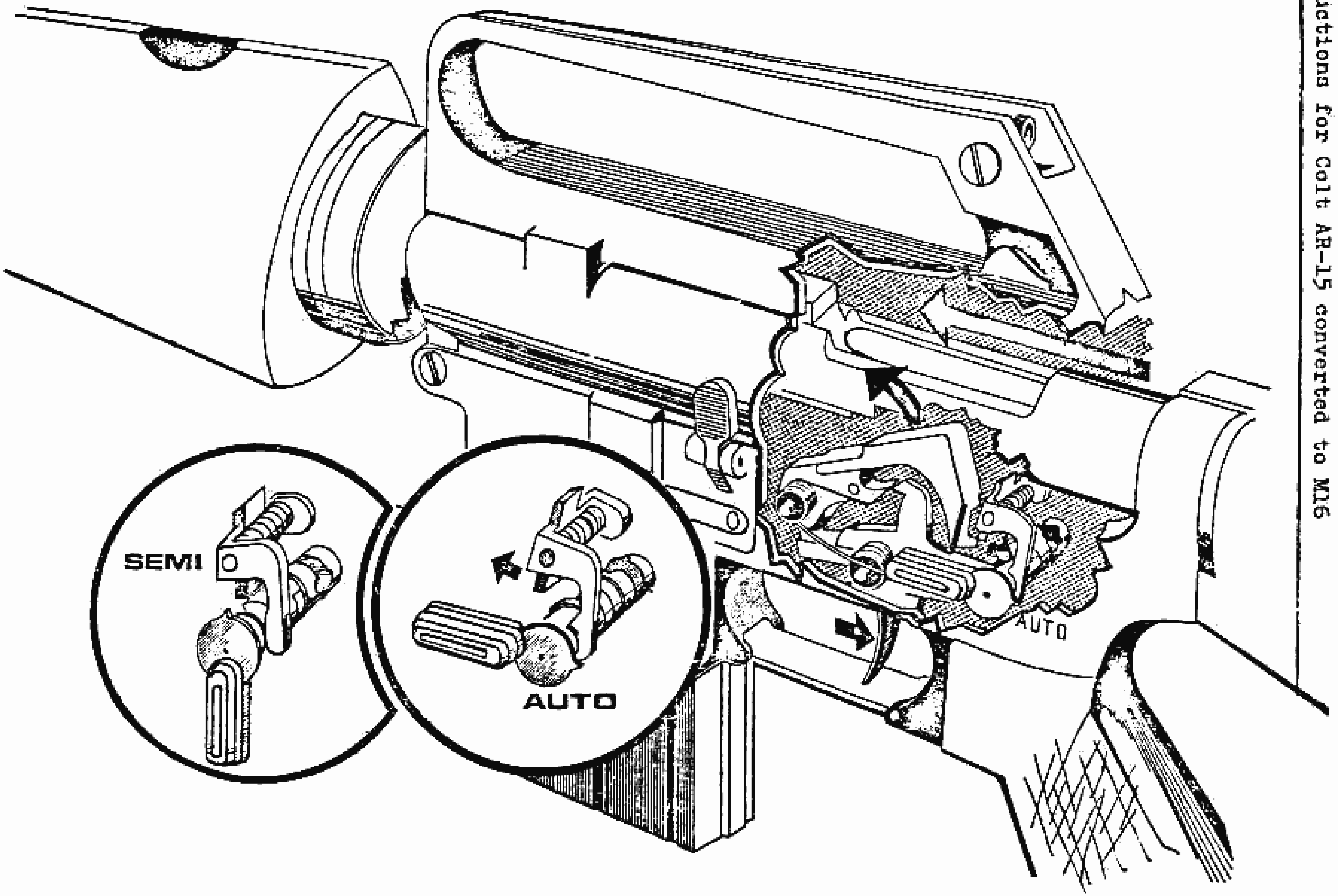
* * *

NOTE : the M16 sear is now positioned in the lower receiver as shown at right. LONG END POINTING DOWN.



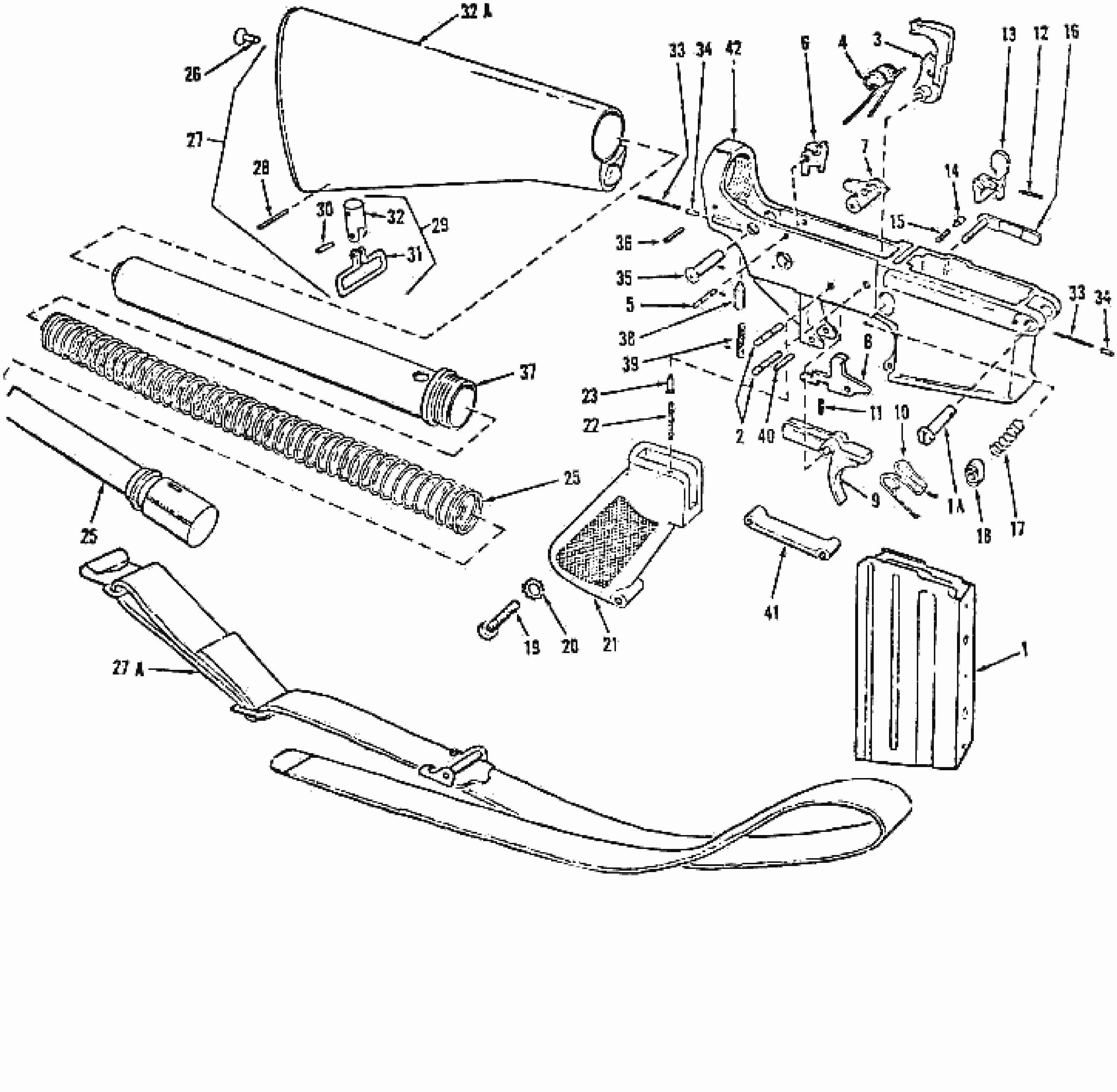
Instructions for Colt AR-15 converted to M16

AUTOMATIC SEAR

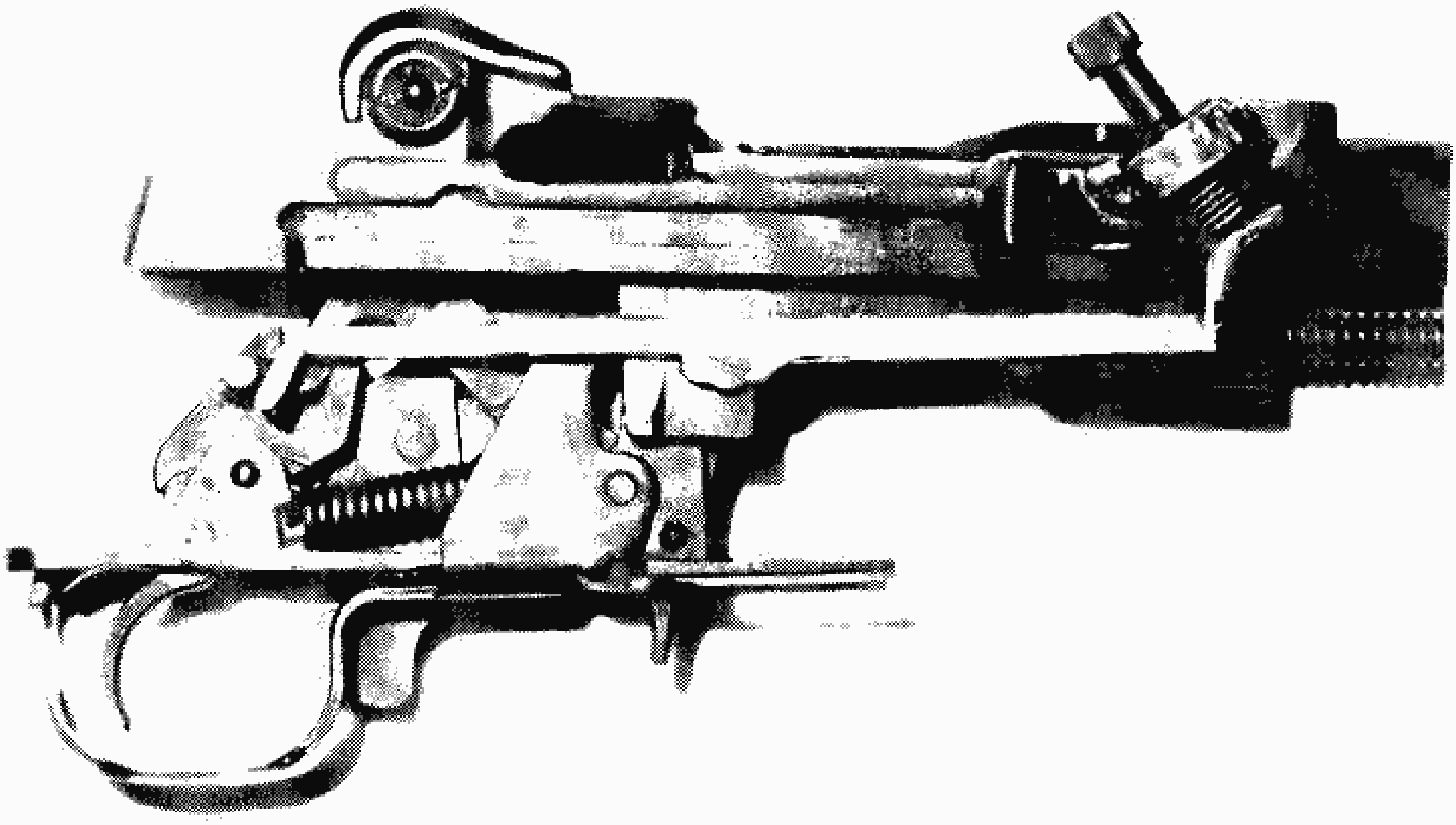

SEMI
AUTO
AUTO

Instructions for Colt AR-15 converted to M16

REFER TO THIS DIAGRAM IF DIFFICULTY IS FOUND WHEN RE-ASSEMLEING THE RIFLE.


32 A
26
27
28
30
32
29
31
33
34
42
6
4
3
13
12
16
7
14
15
36
35
5
38
39
8
23
22
11
10
2
40
9
1A
18
17
37
25
25
33
34
41
19
20
21
1
27 A

MINI-14 SELECTIVE FIRE CONVERSION



The main part of this conversion is the Secondary Sear Trip Lever. This part can be bent or filed to gain the exact fit you need. AT NO TIME ARE YOU TO FILE OFF ANY PART OF THE SEAR!

The average person can make this conversion using ordinary tools. With your weapon on full-auto mode, you can squeeze off single shots by using trigger control. The rate of fire is up to 750 rounds per minute.

In the normal firing cycle, the following actions occur: Starting in a locked and cocked position with a round in the chamber, the trigger is pulled. This causes the primary sear to move forward, disengaging the sear from the hammer. The hammer then moves forward and the weapon fires. Upon firing, the slide and the bolt move to the rear, carrying the hammer to the rear. Since the trigger is still in the rearward position, the primary sear is also in the disengaged position. The secondary sear has moved forward and engaged the hammer. (See figure 2).

When the trigger is released, the primary and secondary sears move to the rear. The secondary sear then disengages and the primary sear engages the hammer. The weapon is then ready to fire.

In full-auto condition the first round is fired normally. The trigger is held to the rear. When the slide and bolt move forward, chambering a round the slide contacts the Secondary Sear Trip Lever (figure 3) which cams the secondary sear to the rear, releasing the hammer. The weapon will continue to fire until the trigger is released and the primary sear engages the hammer.

Contrary to a popular belief, filing the sear is a mistake. It is a dangerous practice and may turn a fine piece of machinery into a booby trap.

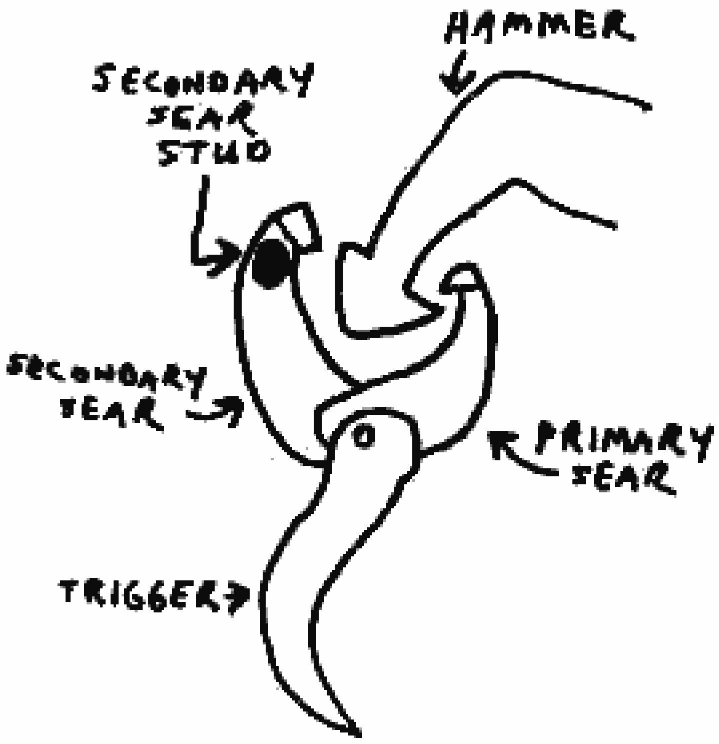

HAMMER
SECONDARY SEAR STUD
SECONDARY SEAR
PRIMARY SEAR
TRIGGER

FIGURE ONE

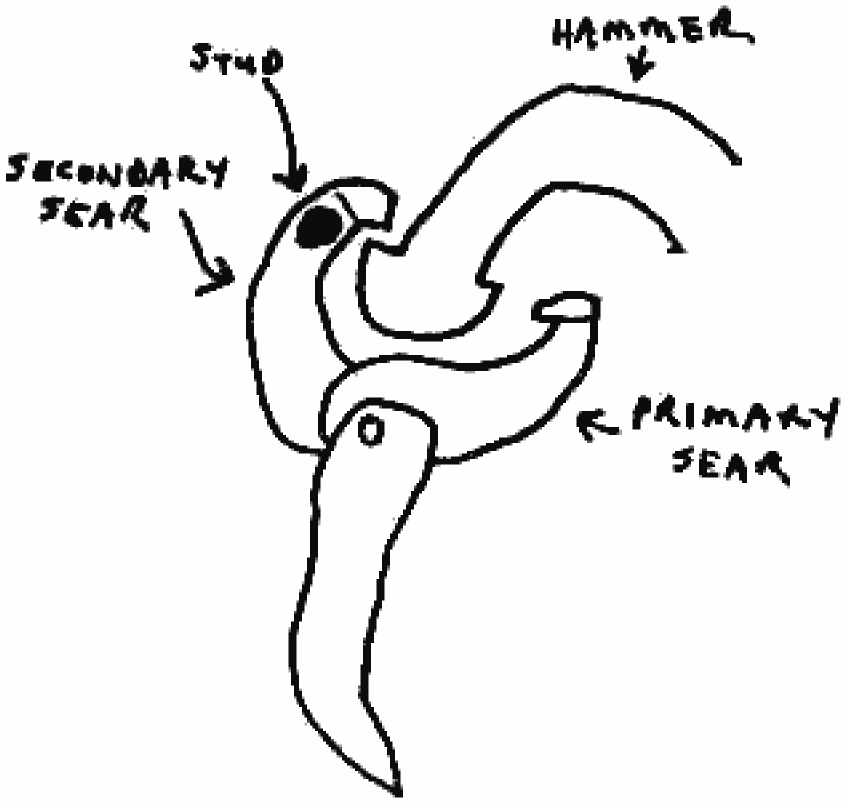

STUD
HAMMER
SECONDARY SEAR
PRIMARY SEAR

FIGURE TWO

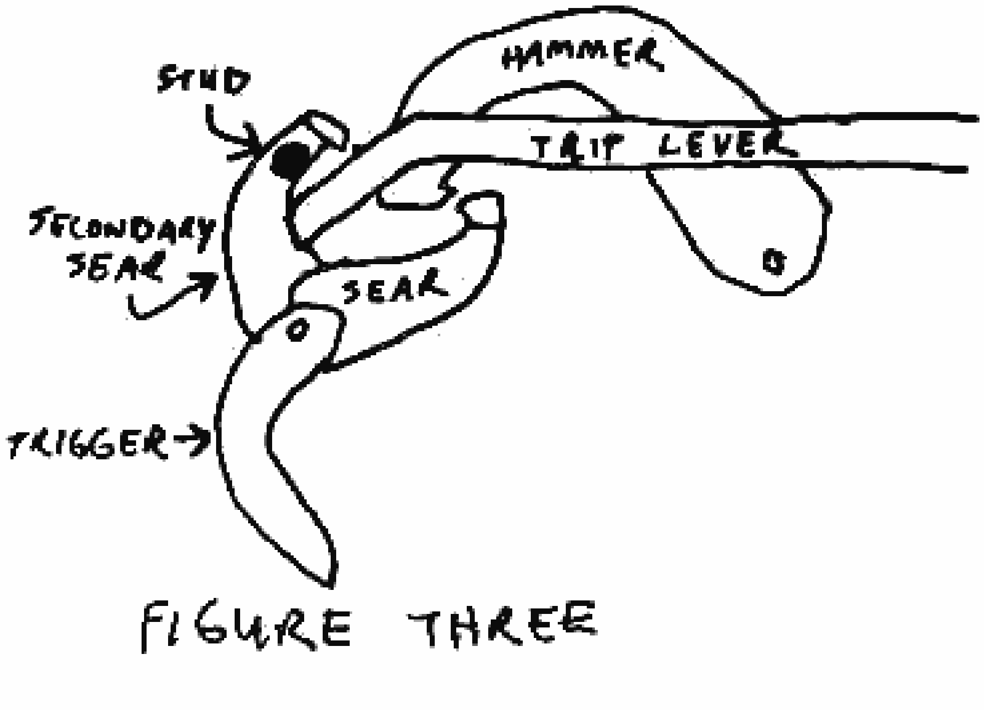
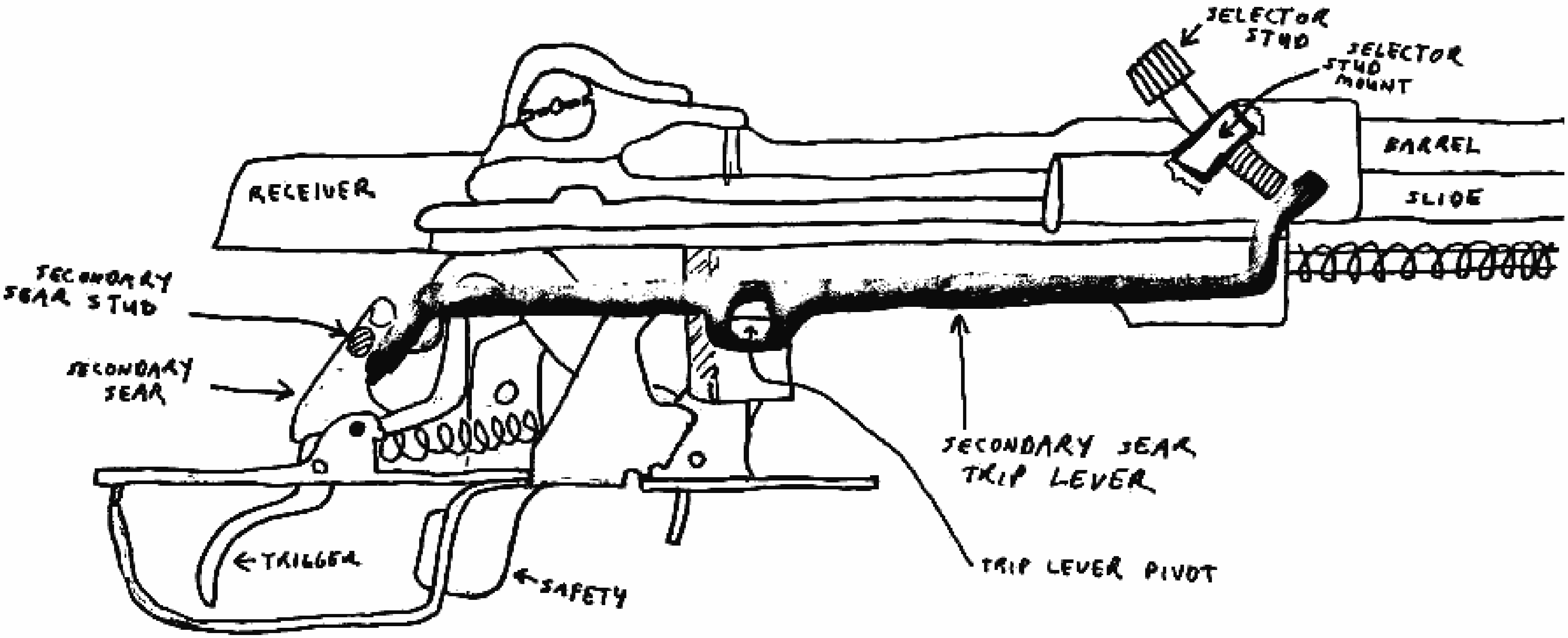

STUD
HAMMER
TRIP LEVER
SECONDARY SEAR
SEAR
TRIGGER

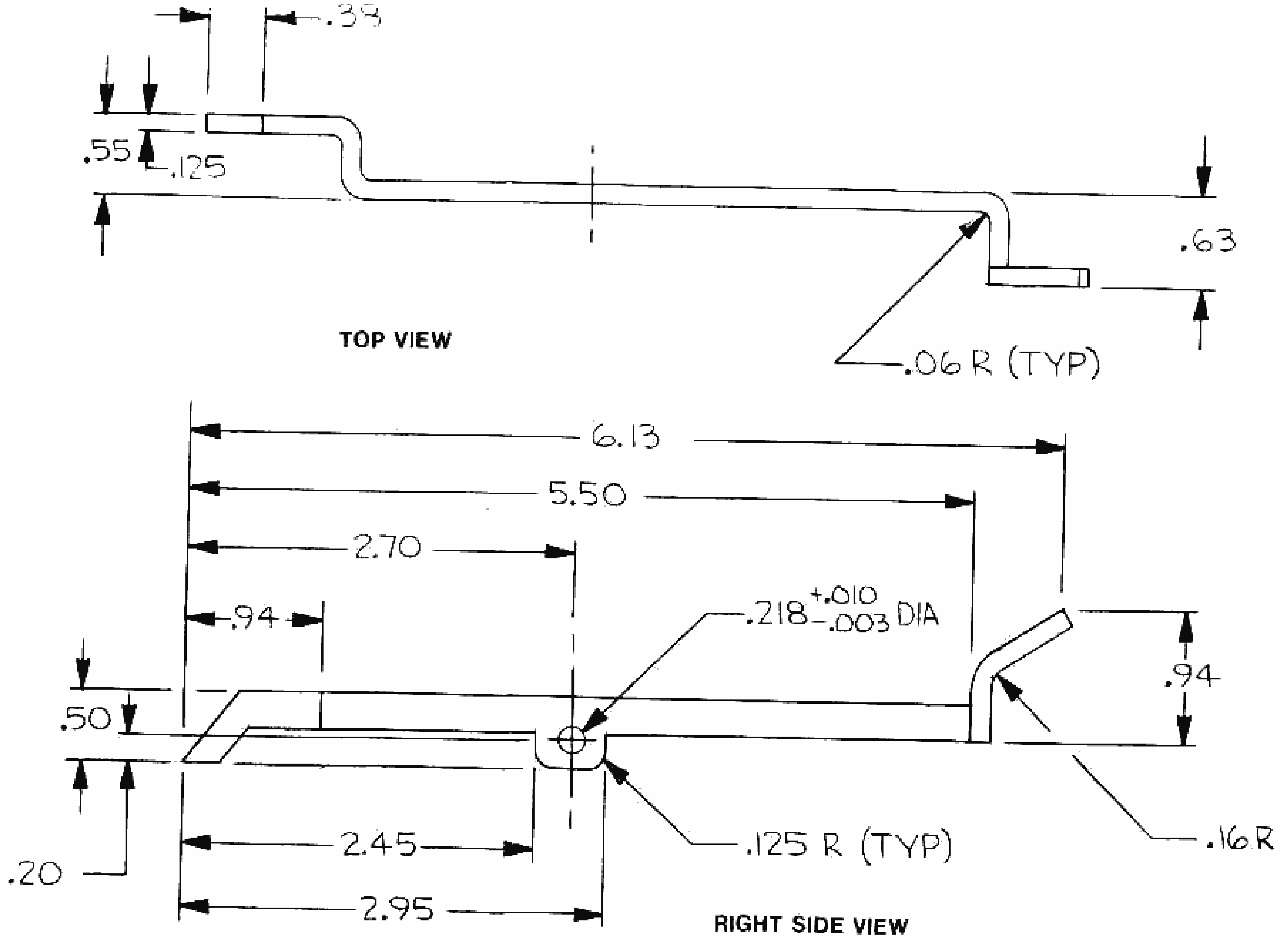
FIGURE THREE

PARTS LIST

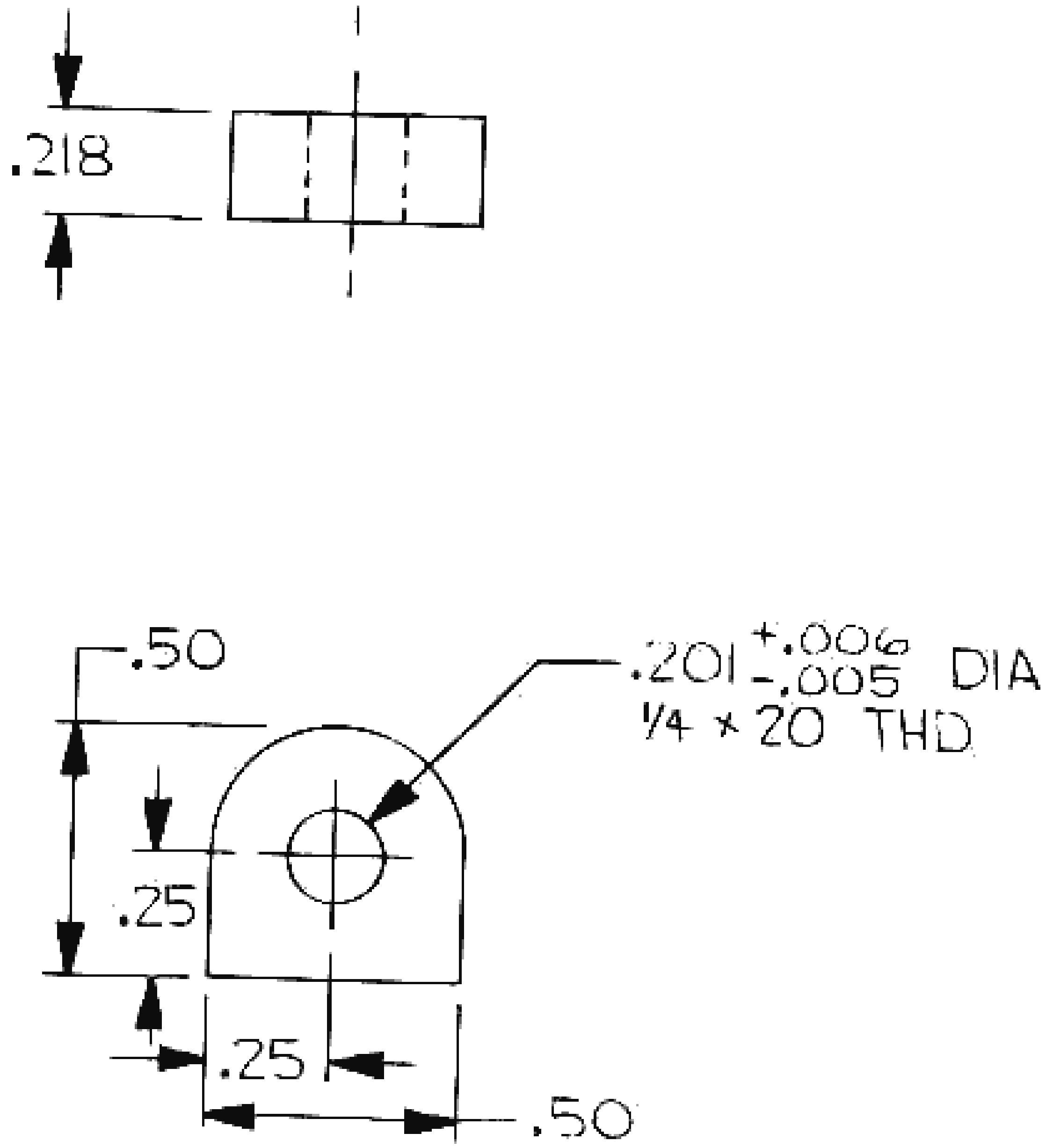
1) Drill Rod, 11/64 or 3/16" diameter, 1/4" long (Secondary Sear Stud).
2) Key Stock or Soft Iron Flat Bar, 1/8" or 3/16" diameter respectively (Secondary Sear Trip Lever).
3) Machine Screw #10-24, 1/2" long, (Secondary Sear Trip Lever Pivot).
4) Set Screw, 1¼ long x 1/4" diameter with #20 thread (Selector Stud).
5) Steel Nut, #20 thread, commercial or hand made (Selector Stud Mount).

-------------- PARTS NOMENCLATURE -----------


SELECTOR STUD
SELECTOR STUD MOUNT
BARREL
SLIDE
RECEIVER
SECONDARY SEAR STUD
SECONDARY SEAR
SECONDARY SEAR TRIP LEVER
TRIP LEVER PIVOT
TRIGGER
SAFETY


.38
.55
.125
.63
.06 R (TYP)
TOP VIEW
6.13
5.50
2.70
.94
.218 $^{+.010}_{-.003}$ DIA
.94
.50
.20
2.45
.125 R (TYP)
.16 R
2.95
RIGHT SIDE VIEW

SECONDARY SEAR TRIP LEVER
SCALE: 1/1


.218
.50
.201 +.006 -.005 DIA
1/4 x 20 THD
.25
.25
.50

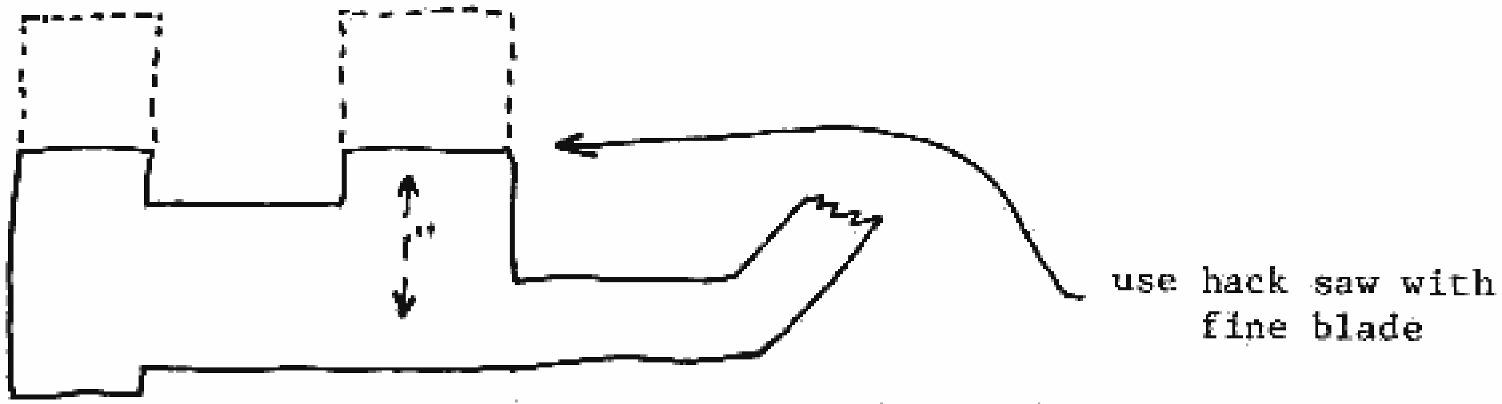
SCALE: 2/1

SELECTOR STUD MOUNT
STEEL

The first step is to basically field strip your weapon, the next page offers some additional guidance.

1) remove the magazine
2) pull the cocking lever to the rear and release, put safety on
3) open trigger guard latch
4) remove trigger group
5) remove barrel and receiver group from stock
6) remove recoil spring and guide
7) remove slide
8) remove stock reinforcement from stock

Take the stock reinforcement and cut off two pieces with a hack saw as shown below from the right side:



STOCK REINFORCEMENT RIGHT SIDE

The above procedure will allow clearance for the Trip Lever.

Replace the Stock Reinforcement

FIELD STRIPPING

1. Remove magazine (Fig. C).

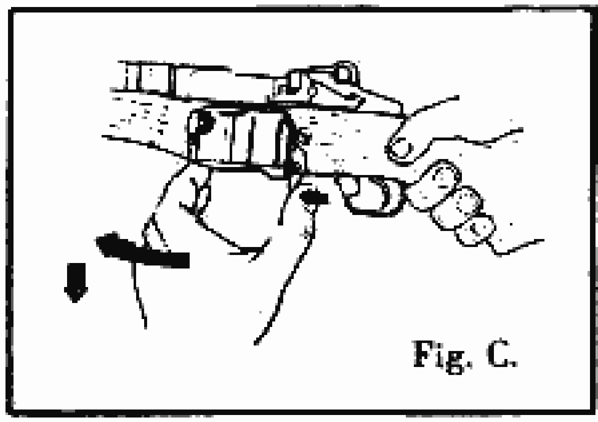


Fig. C.

2. Pull cocking handle entirely to rear and release. Put Safety "On", (Fig.D). (Note: Hammer must be cocked and Safety must be "On" to accomplish disassembly and reassembly).

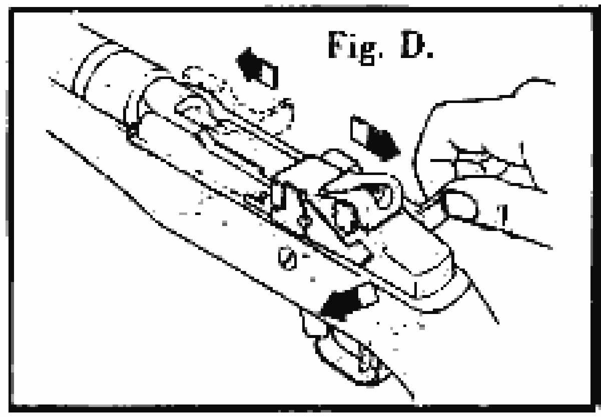


Fig. D.

3. Using a cartridge or other suitable tool, spring open trigger guard latch (Fig. E).

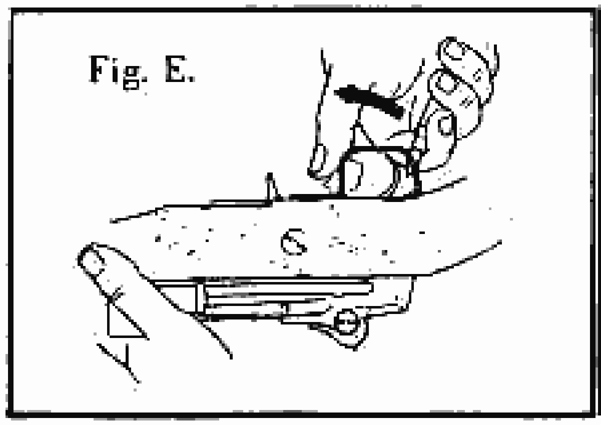


Fig. E.

4. Remove trigger group (Fig. F).

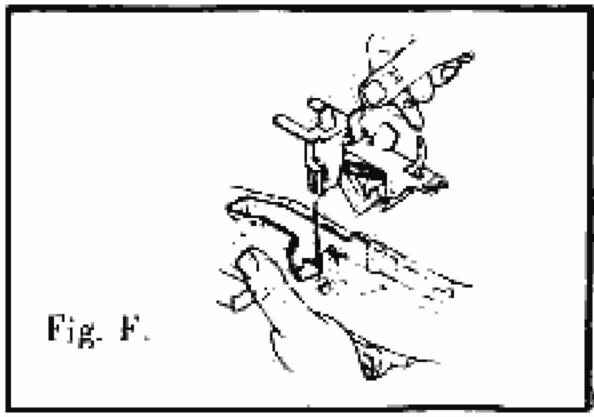


Fig. F.

5. Remove Barrel/receiver assembly from stock (Fig. C).

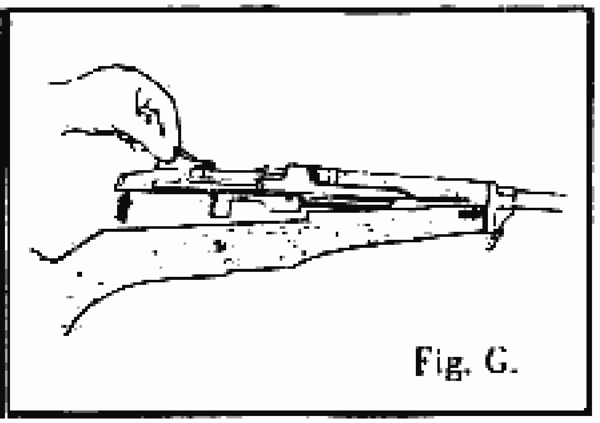


Fig. G.

6. Remove Recoil spring guide and recoil spring (Fig. H1 and 2). Caution: Mainspring is heavily compressed — Use care while disassembling or reassembling to prevent mainspring assembly from escaping and possibly causing injury.

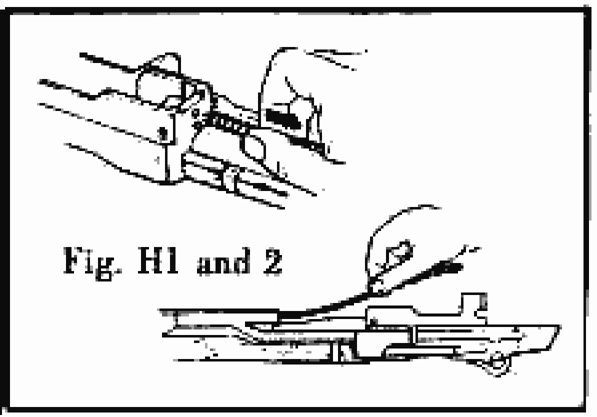


Fig. H1 and 2

7. Pull slide handle to the rear. Align locking projections on slide with disassembly notch on receiver. Remove slide (Fig. I).

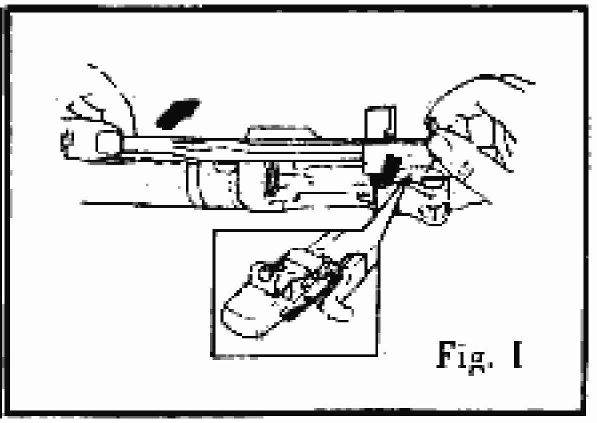


Fig. I

8. Pull the bolt forward until it pivots out of the receiver. Align firing pin projection with slot in lower receiver bridge. Remove bolt (Fig. J).

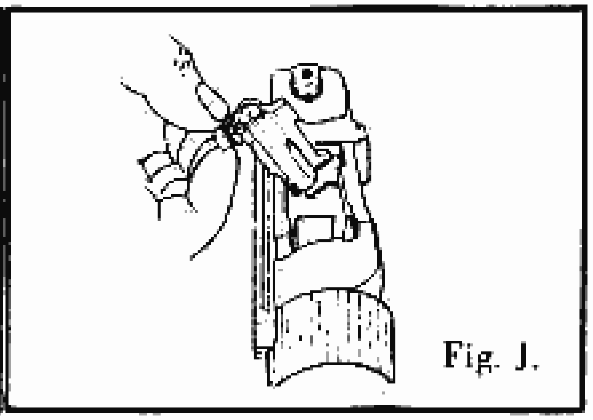
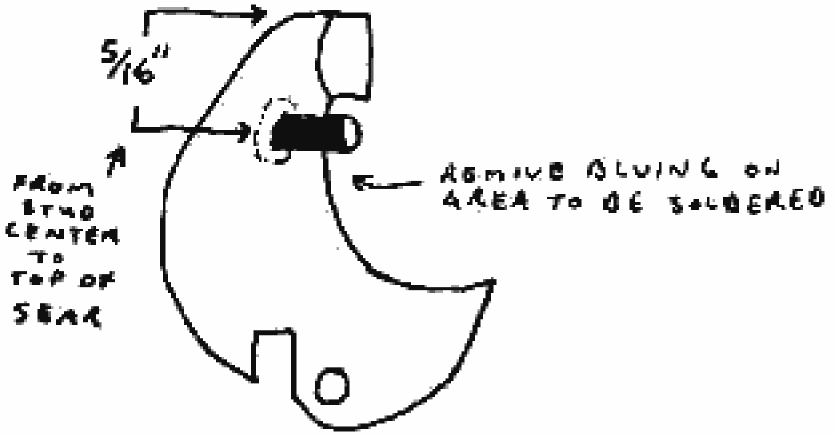


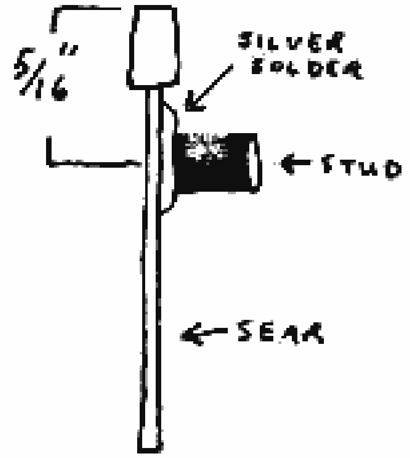
Fig. J.

Further disassembly should not be required and is not recommended unless performed by competent persons experienced in gunsmithing.

Remove Secondary Sear


5/16"
FROM STUD CENTER TO TOP OF SEAR
REMOVE BLUING ON AREA TO BE SOLDERED

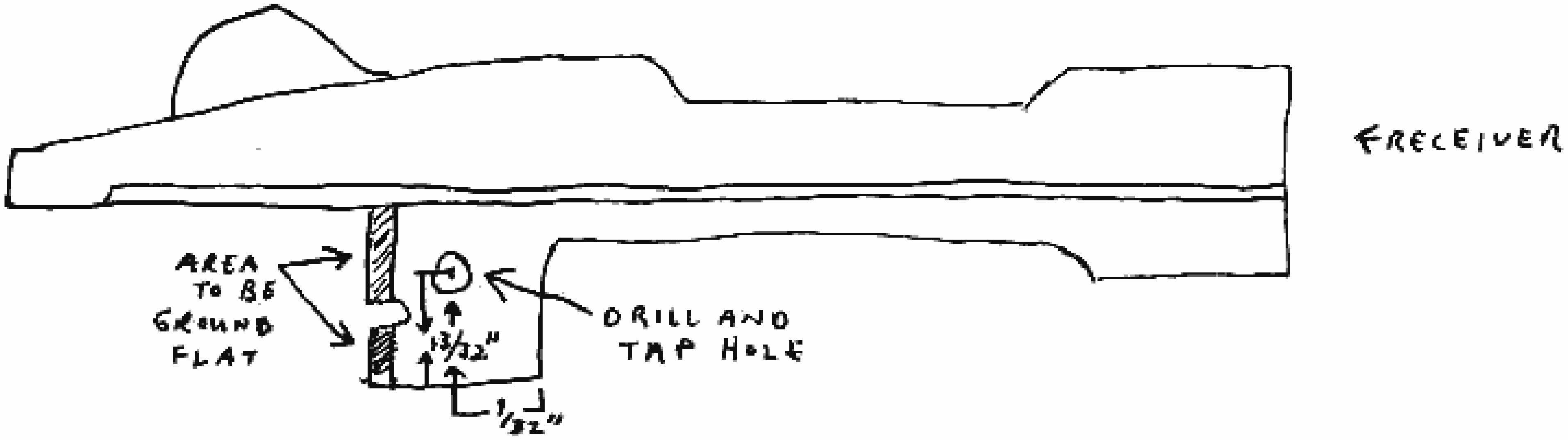
very carefully silver solder Stud to sear as shown


5/16"
SILVER SOLDER
STUD
SEAR

When soldering, follow directions on the Flux container and properly apply flux to sear, place Sear Stud on flux and then solder using a good propane or acetylene torch.

Replace Secondary Sear

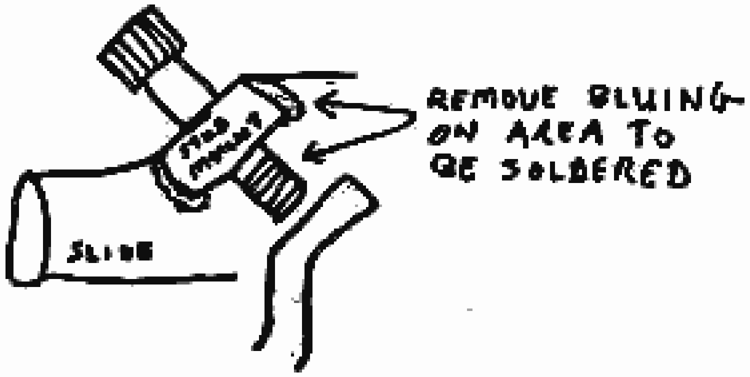
Taking the Receiver, drill and tap #10-24 hole for Trip Lever Pivot. You might mark your drilling spot with a center punch. Use a 1/8 or #9 drill bit. Use a #10-24 starter tap.


RECEIVER
AREA TO BE GROUND FLAT
DRILL AND TAP HOLE
13/32"
1/32"

Grind metal from receiver to provide clearance for Trip Lever. A disk grinder or a file will do this well. Once the hole is drilled, use a #10-24 starter tap to thread the hole with.

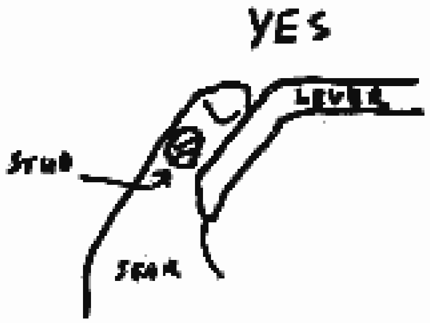
Now using the Trip Lever Pivot, install the Trip Lever. Once the Pivot Screw is tight, you will want to cut off and file flush any exposed threads from the inner side as to not interfere with the magazine track. Also it is advisable to use Loc-Tight to insure the Pivot stays in place in a FIRE FIGHT.

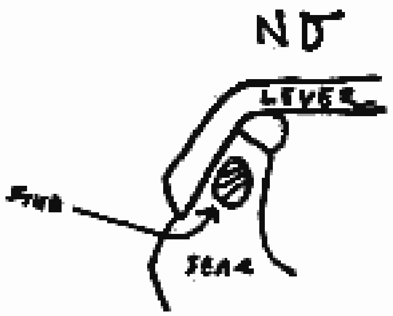
Using the Parts Nomenclature diagram as a guideline, silver solder the Selector Stud Mount to the Slide.



The Trip Lever must be in place. When aligning the Mount, insert the Stud to get accurate alignment. Remove the Stud before actually soldering the Mount to the Slide.

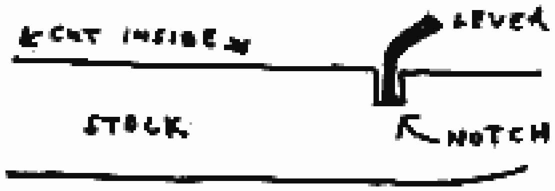
Install the Trigger Group onto the receiver, when you do this be sure the Trip Lever stays in proper configuration with the Sear Stud as shown below.





Install Recoil Spring and Operating Slide.

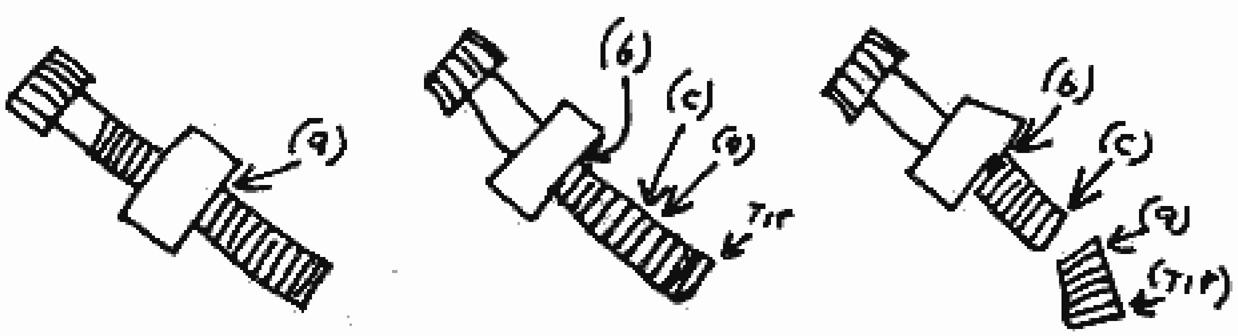
Now inlet the stock for clearance of the Trip Lever. Do this by aligning the stock and barrel/receiver assembly, then using a chisel or similar wood working tool, make the proper cuts. In addition to the obvious cut-out on the outside, it is necessary to cut-out an area on the inside on the right side to allow clearance for the Trip Lever.



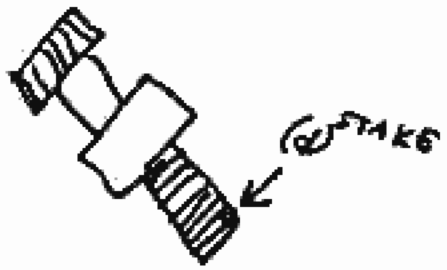
Now assemble the weapon

Partially screw in the Selector Stud. You are now ready to make the final adjustment. Place the safety in the Fire position, depress the trigger and leave it depressed until I tell you to let it up. Pull the slide to the rear and release it, screw down the Selector Stud until the Secondary Sear is disengaged and the hammer falls, at this point the weapon is on AUTOMATIC. NOW YOU CAN LET UP ON THE TRIGGER.

A) Now at this point, measure the amount of thread between the Stud Mount and the Trip Lever (a) and mark it, then tighten the Stud all the way down, take measurement (a) and measure from point (b) toward the tip, you will be at point (c), cut off the excess from point (c) toward the tip. Now when the Stud is tight, the weapon will be on AUTO and when it is backed off it will be on SEMI. You could stake the end of the Stud with a center punch or chisel, this will provide a stop for the Selector Stud when it is backed out in the SEMI position, see (d).



THE DISTANCE BETWEEN
(b) and (C) IS THE SAME
AS BETWEEN (a) and (TIP)

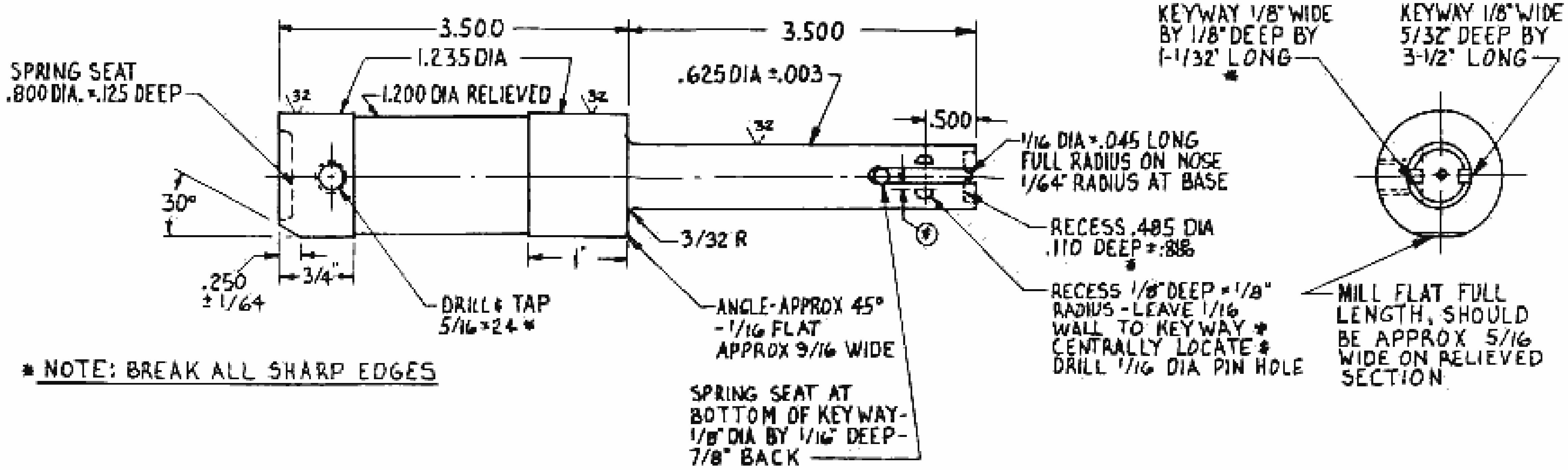


You are now ready to test fire your weapon.

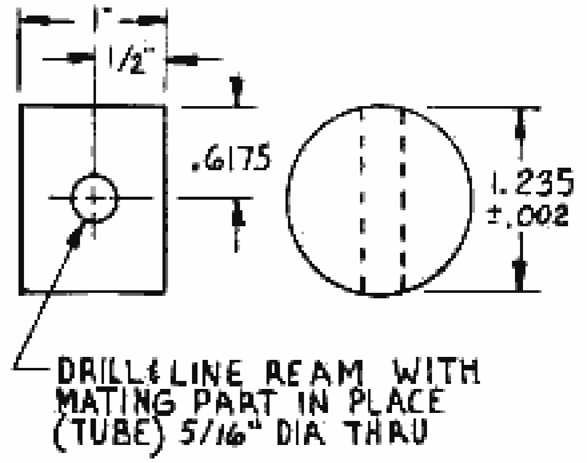
Complete Construction Plans for the MARK-1 SUB-MACHINE GUN

Scale Drawings - Parts List

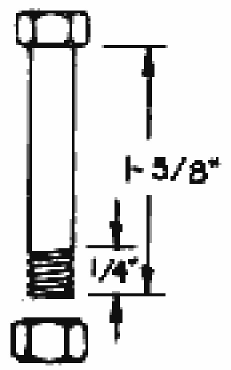
1. (1) brl. cal. .45 blank .750 dia.
2. (1) 16½" seamless tubing 1.250 I.D./.062 wall (@ $1.25 ft.) — Approximately
3. (2) Aluminum bar "6061 or 2024 -1¼ diameter (3" needed per) @50c per lb.
4. (1) ½" wide x 1/8" thick iron strap @ $1.25 per 20' — Approximately.
5. (2) ¾" wide x 1/8 thick iron strap @ $1.30 per 20' — Approximately
6. (1) Steel bar (C/R or H.S.T.) 6½' pr
7. (1) Steel Spring (diameter 1-1/8 to 1-3/16 x 10" long
8. (1) 5/16" x 18" bolt (1-3/8" long) & nut
9. (1) 10 x 32 Allen set screw ¼" long
10. (3) 10 x 32 ovalhead screw ¼" long
11. (2) Pins ¼" diameter & 3/16" diameter (1" long)
12. (2) Cotter pins 1/16" diameter ½" long @15c for 40 pins.
13. (1) 1/16" thick sheet-metal 3¼" x 6"
14. (1) 5/16" x 24" bolt 1½" long
15. (1) 5/8" wide x ¼" thick Steel Cold Roll or Hot Roll Steel
16. (1) Spring 3/8" diameter x 3/8" long
17. (1) pin, ¾" long x 1/8" diameter (Steel drill rod)
18. (1) ¾" x ¾" Square tubing (Steel with .062 wall) 2" per
19. (1) Wood 1½" wide x ¾ thick x 5" long, preferably hardwood.
20. (2) Wood screws 1/8" diameter x ½" long
21. (1) Front sight; make or buy
22. (1) Rear sight; make or buy


3.500
3.500
1.235 DIA
1.200 DIA RELIEVED
.625 DIA ±.003
.500
SPRING SEAT
.800 DIA. × .125 DEEP
32
32
32
30°
.250
±1/64
3/4"
1"
3/32 R
DRILL & TAP
5/16×24 *
ANGLE-APPROX 45°
-1/16 FLAT
APPROX 9/16 WIDE
SPRING SEAT AT
BOTTOM OF KEYWAY-
1/8" DIA BY 1/16" DEEP-
7/8" BACK
1/16 DIA × .045 LONG
FULL RADIUS ON NOSE
1/64" RADIUS AT BASE
RECESS .485 DIA
.110 DEEP ± .005 *
RECESS 1/8" DEEP × 1/8"
RADIUS - LEAVE 1/16
WALL TO KEYWAY *
CENTRALLY LOCATE &
DRILL 1/16 DIA PIN HOLE
KEYWAY 1/8" WIDE
BY 1/8" DEEP BY
1-1/32" LONG *
KEYWAY 1/8" WIDE
5/32" DEEP BY
3-1/2" LONG
MILL FLAT FULL
LENGTH, SHOULD
BE APPROX 5/16
WIDE ON RELIEVED
SECTION
* NOTE: BREAK ALL SHARP EDGES

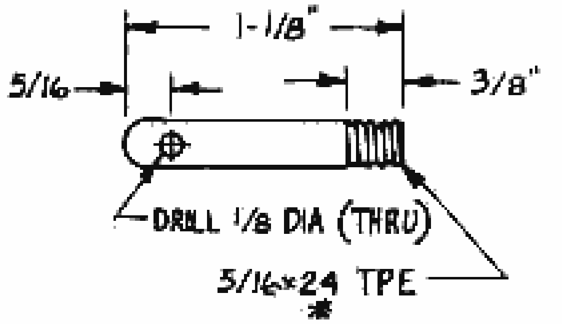
BREECH-BLOCK INTL-HRS/ C/HARDEN .010-.015 DEPTH


1"
1/2"
.6175
1.235
±.002
DRILL & LINE REAM WITH
MATING PART IN PLACE
(TUBE) 5/16" DIA THRU

RETAINING PLUG-MTL 6061-T6 ALUM

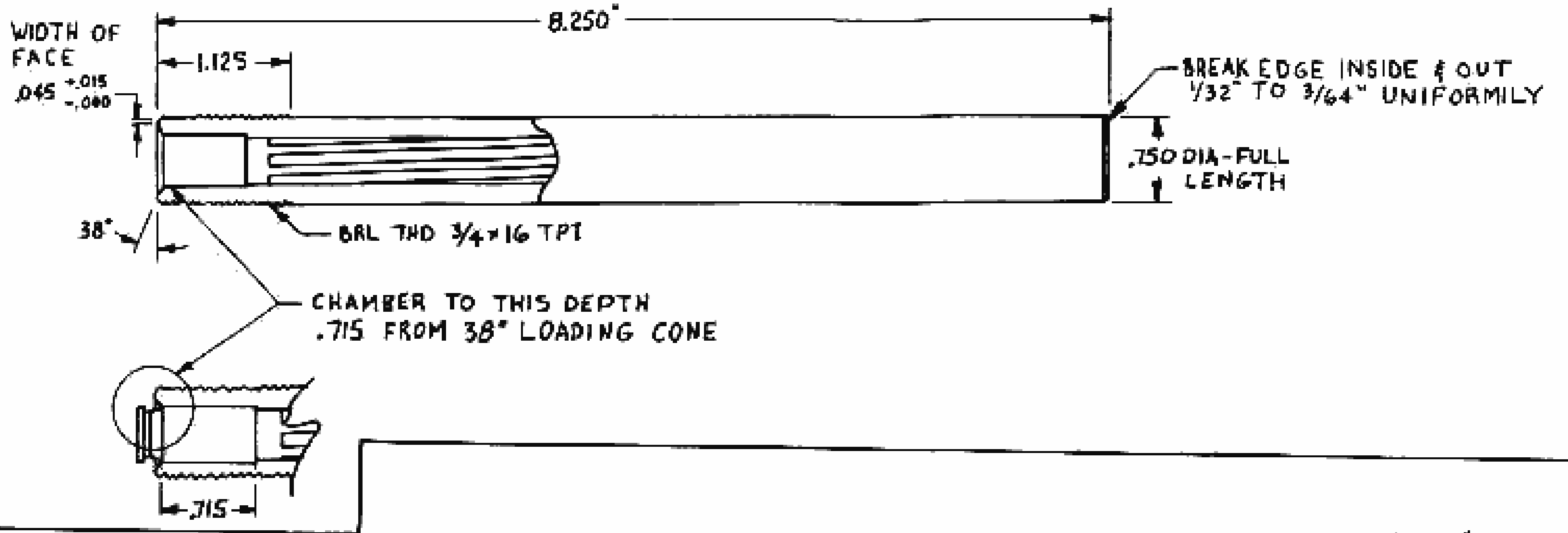


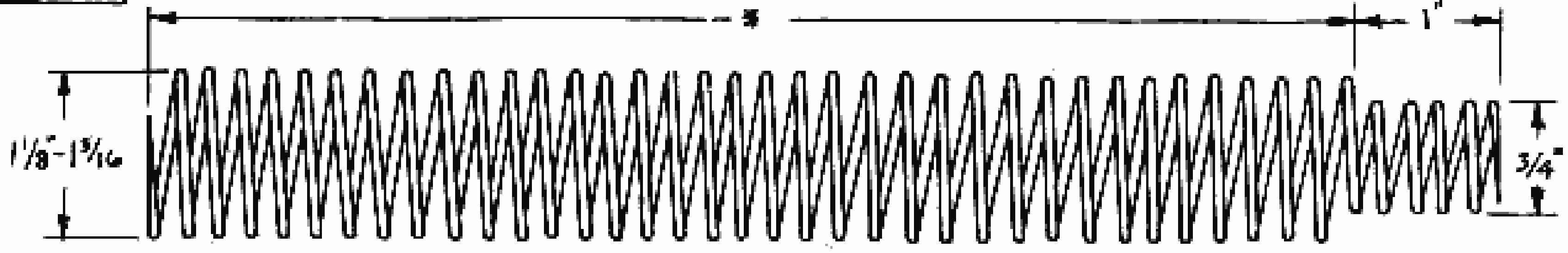
RETAINING PLUG BOLT & NUT
5/16×18 STL PURCHASED
(HEX HEAD) & NUT - SELF LOCKING


1-1/8"
5/16
3/8"
DRILL 1/8 DIA (THRU)
5/16×24 TPE *

COCKING KNOB-MTL 5/16 BOLT-STL

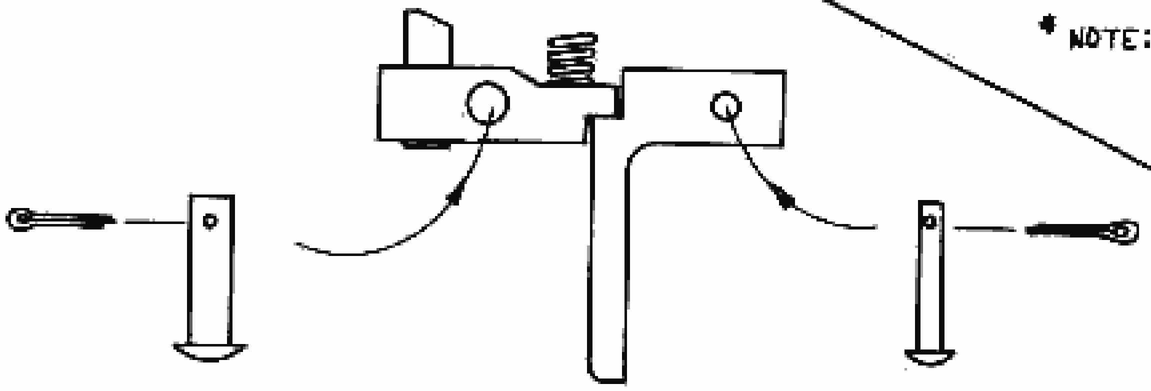
SMG PLANS SHEET No. 1


WIDTH OF FACE
.045 +.015 -.000
8.250"
1.125
BREAK EDGE INSIDE & OUT 1/32" TO 3/64" UNIFORMILY
.750 DIA-FULL LENGTH
38°
BRL THD 3/4×16 TPT
CHAMBER TO THIS DEPTH .715 FROM 38° LOADING CONE
.715


*
1"
1 1/8"-1 3/16
3/4"

THRUST SPRING-STL-NON-FATIGUING (PURCHASED)

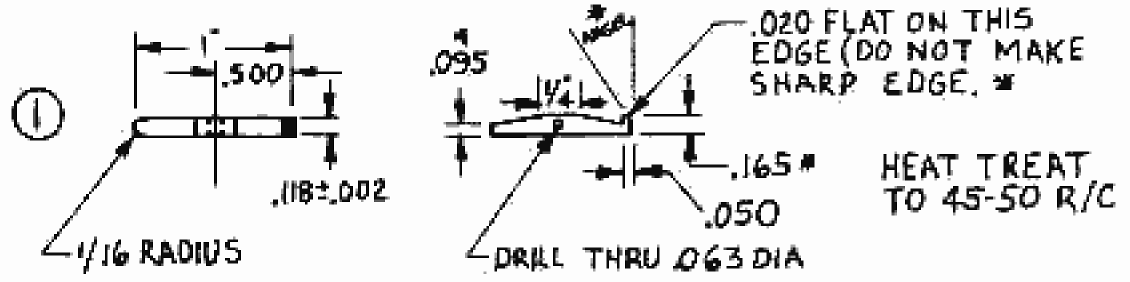
* NOTE: LENGTH OF SPRING & TENSION WILL HAVE TO BE ADJUSTED-DEPENDING ON TYPE SPRING USED SHOULD BE APPROX 9 1/2" LONG



ASSEMBLY OF TRIGGER & SEAR IN PROPER RELATION WITHIN HOUSING

SMG PLANS SHEET No. 2

* EXTRACTOR, PIVOT PIN & SPRING (INT'L STEEL)


①
1"
.500
.118±.002
1/16 RADIUS
* .095
1/4
* MAX
.020 FLAT ON THIS EDGE (DO NOT MAKE SHARP EDGE. *
.165 *
.050
DRILL THRU .063 DIA

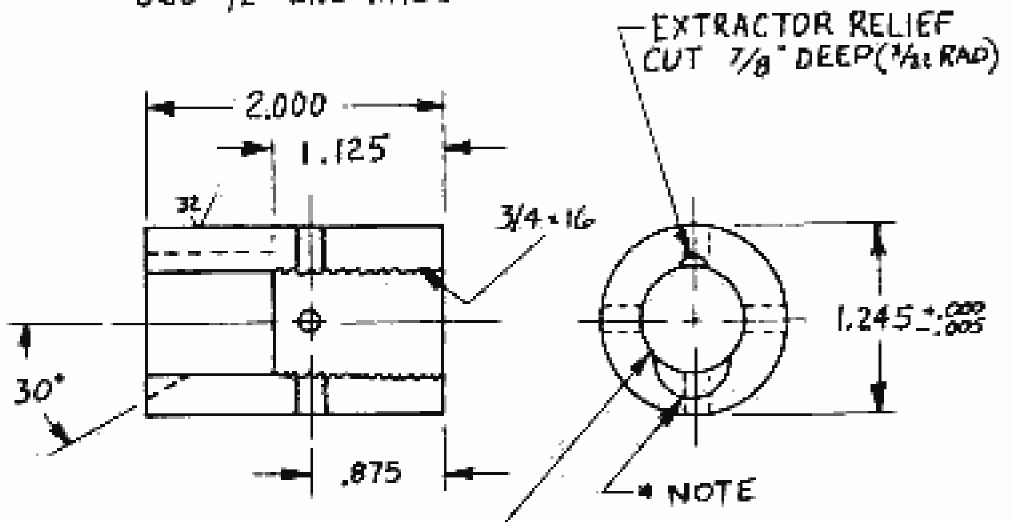
HEAT TREAT TO 45-50 R/C

NOTE: THIS PART MIGHT REQUIRE SOME HAND FITTING - (1/32"-3/64" LIP TO SNAP INTO EXTRACTOR GROOVE IN CASE)

② *EXTRACTOR PIN .062 DIA. x .275 LONG (STL)

③ *EXTRACTOR SPRING .110-.120 DIA. x 1/8" LONG

*NOTE: LOADING RAMP CUT USE 1/2" END MILL

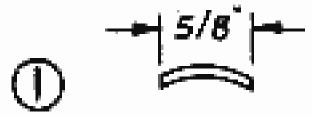

EXTRACTOR RELIEF CUT 7/8" DEEP (3/32 RAD)
2.000
1.125
32
3/4×16
30°
.875
1.245 +.000 -.005
* NOTE

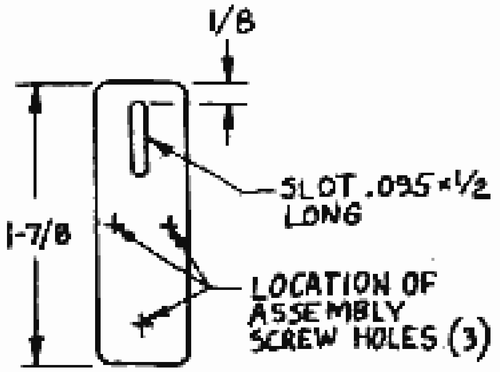
THIS SERIES OF HOLES (4) LOCATED 90° APART — THE ONE LOCATED 180° FROM THE 30° CUT, IS THE BARREL LOCK SCREW AND HAS TO BREAK THRU. (4) D&T #10-32

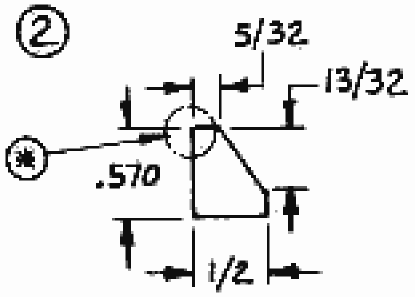
NOTE: DRILL THRU WITH 23/32" THREADED SECTION WILL NOT HAVE FULL DEPTH OF THREAD - BUT SUFFICIENT

LOADING RAMP & BARREL ALIGNMENT PLUG- MTL 6061-T6 ALUM

EJECTOR ASSEMBLY, MTL STL

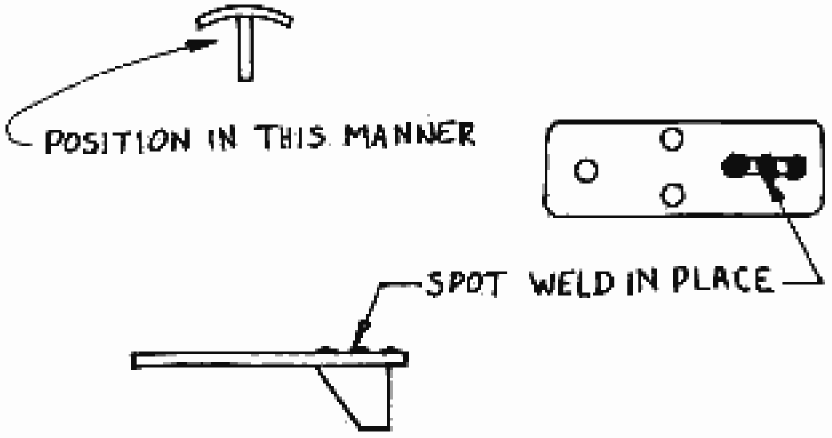



1/8
1-7/8
SLOT .095×1/2 LONG
LOCATION OF ASSEMBLY SCREW HOLES (3)

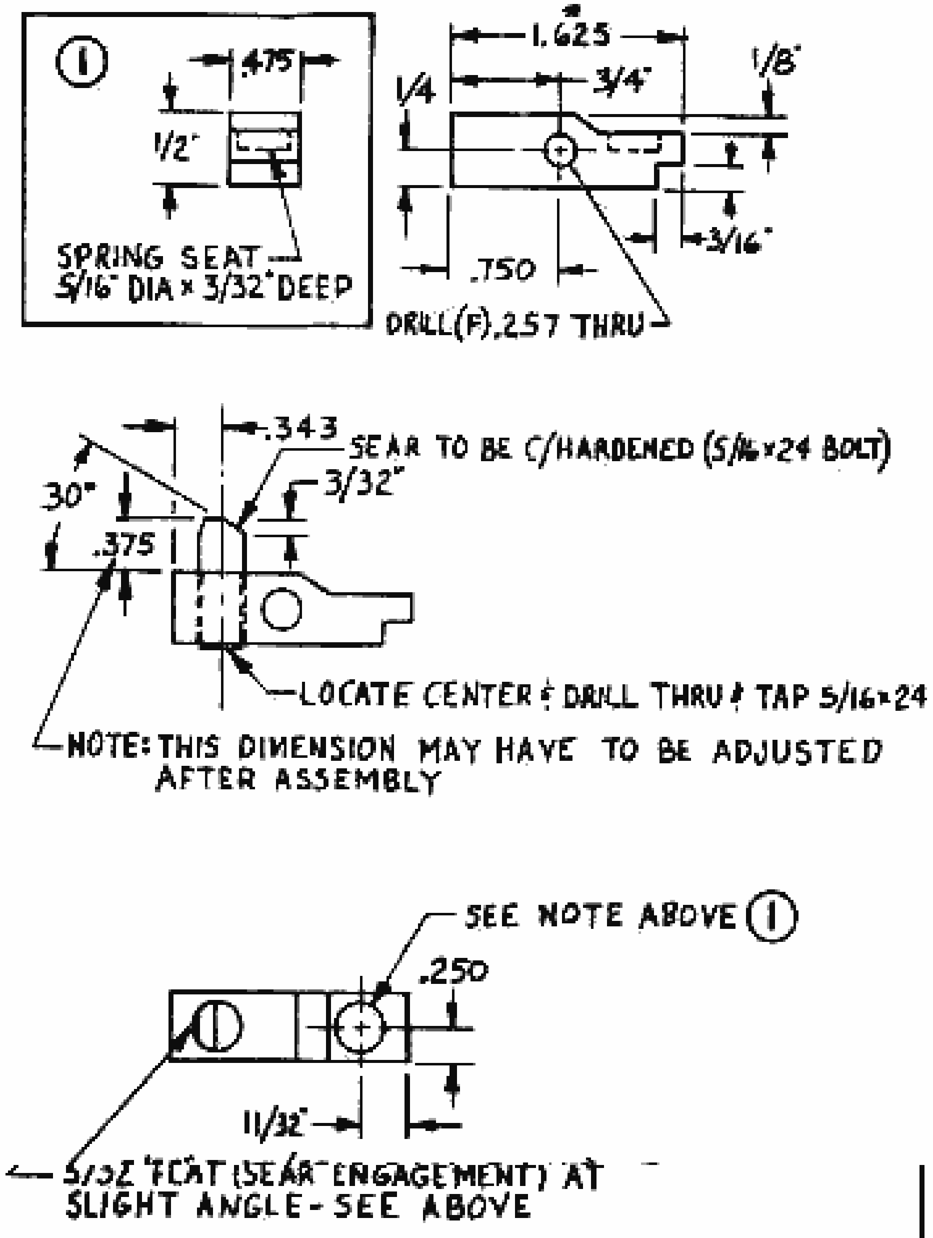

②
5/32
13/32
✱
.570
1/2

① THIS PART CAN BE MADE FROM THE SAME TUBING AS THE HOUSING (THE RADIUS WILL FIT)

② THIS PART OF (.095) FLAT STOCK HARDENED OR CASE/HARDENED AS NOTED ✱


POSITION IN THIS MANNER
SPOT WELD IN PLACE

SEAR, SEAR PIVOT PINS & SPRING STL MILD 1/2" × 1/2"


①
.475
1/2"
SPRING SEAT 5/16" DIA × 3/32" DEEP
1.625
3/4"
1/4
1/8"
.750
3/16"
DRILL(F).257 THRU
.343
30°
3/32"
.375
.250
11/32"

SEAR TO BE C/HARDENED (5/16×24 BOLT)

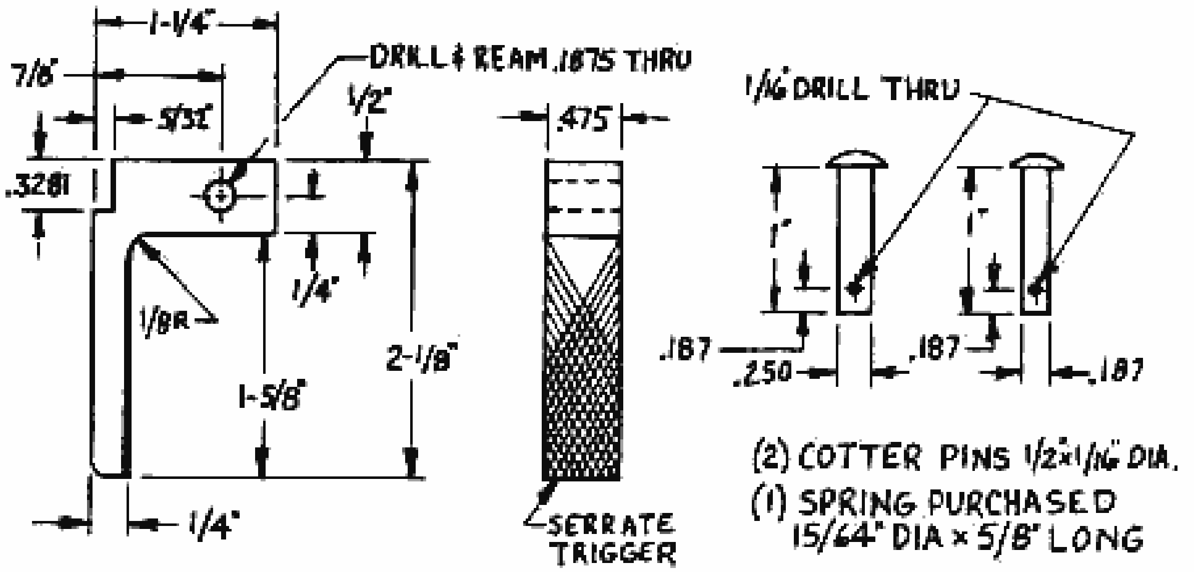
LOCATE CENTER & DRILL THRU & TAP 5/16×24

NOTE: THIS DIMENSION MAY HAVE TO BE ADJUSTED AFTER ASSEMBLY

SEE NOTE ABOVE ①

5/32 FLAT (SEAR ENGAGEMENT) AT SLIGHT ANGLE - SEE ABOVE

TRIGGER-MTL-ALUM 6061 FLAT SLK

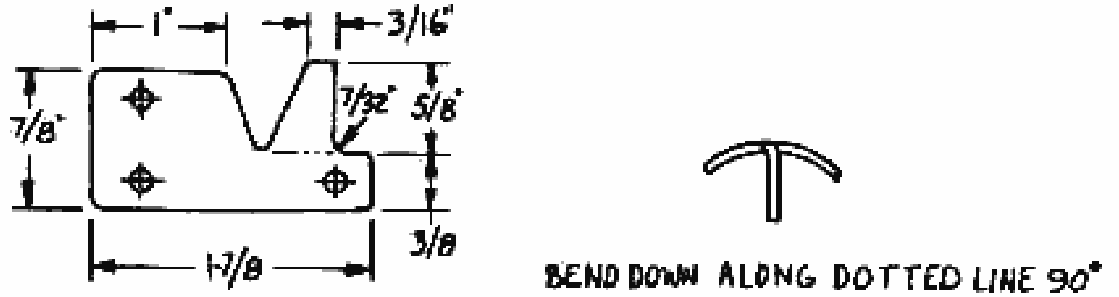

1-1/4"
7/8"
5/32"
.3281
DRILL & REAM .1875 THRU
1/2"
.475
1/16 DRILL THRU
1/4"
1/8R
1-5/8"
2-1/8"
1/4"
SERRATE TRIGGER
1"
1"
.187
.250
.187
.187

(2) COTTER PINS 1/2×1/16 DIA.

(1) SPRING PURCHASED 15/64" DIA × 5/8" LONG

BREAK SHARP EDGES

EJECTOR - 1/16" THICK SHEET METAL. CAN BE CUT FROM SAME MATERIAL AS HOUSING, AS RADIUS MATCHES

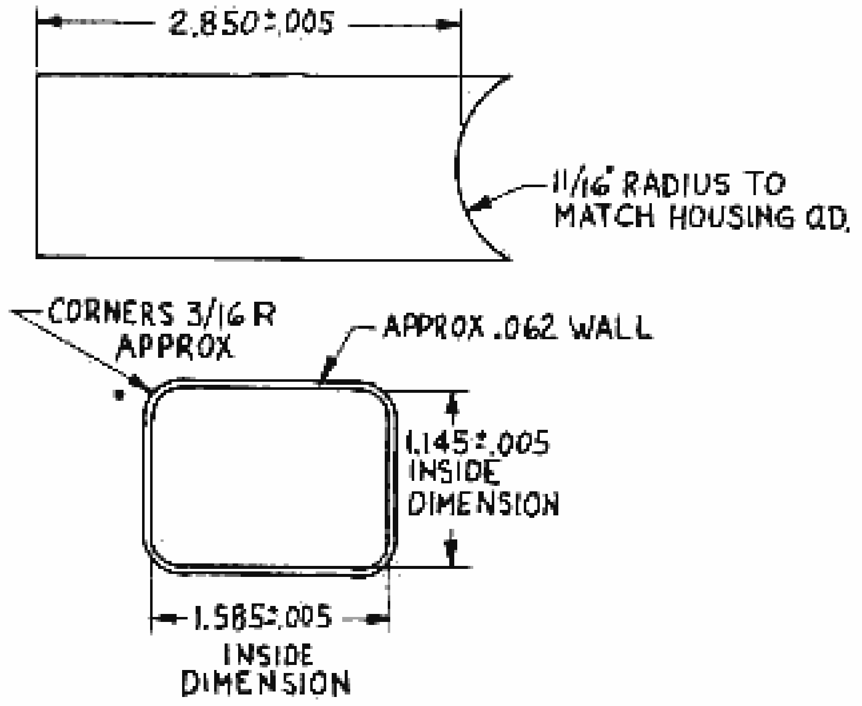

1"
3/16"
7/8"
7/32"
5/8"
3/8
1-7/8

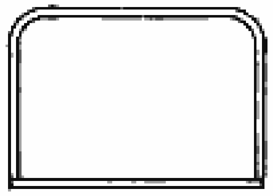
BEND DOWN ALONG DOTTED LINE 90°

(3) CLEARANCE HOLES FOR 6-32 SCREWS, APPROX IN THE ABOVE LOCATIONS. SCREW LENGTH FROM HEAD 1/8" LONG.

SMG PLANS SHEET No. 4

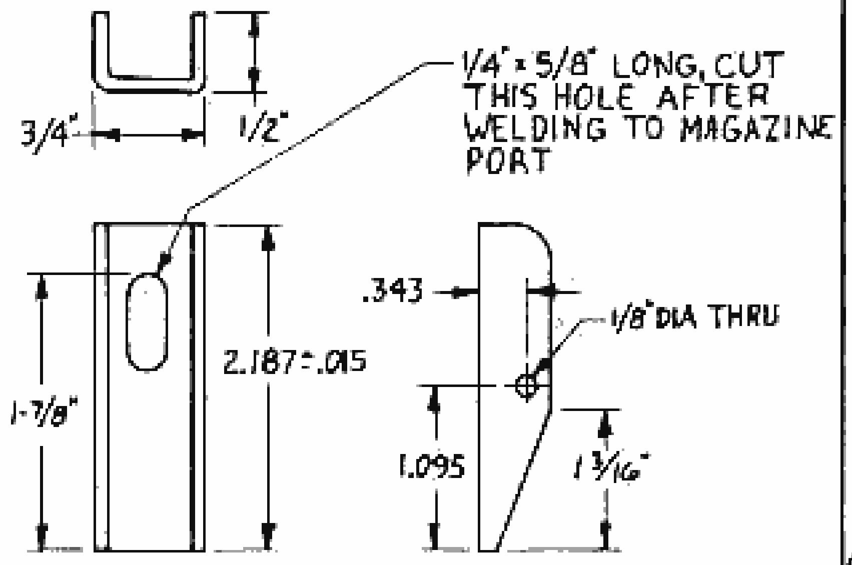
MAGAZINE HOUSING, MTL .062 SHEET METAL


2.850±.005
11/16" RADIUS TO MATCH HOUSING O.D.
CORNERS 3/16 R APPROX
APPROX .062 WALL
1.145±.005 INSIDE DIMENSION
1.585±.005 INSIDE DIMENSION

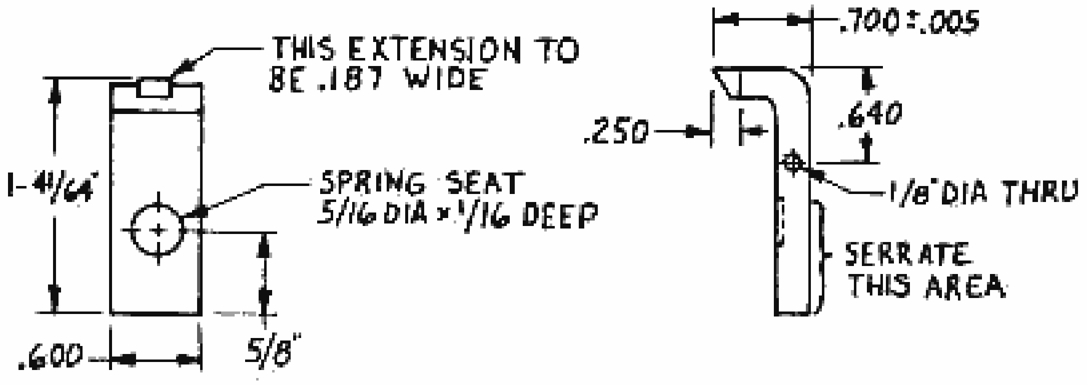


WILL WORK VERY WELL CONSTRUCTED IN THIS THIS MANNER, BY SPOT WELDING PLATE ALONG SIDES (FULL LENGTH)

MAGAZINE RELEASE, STL.

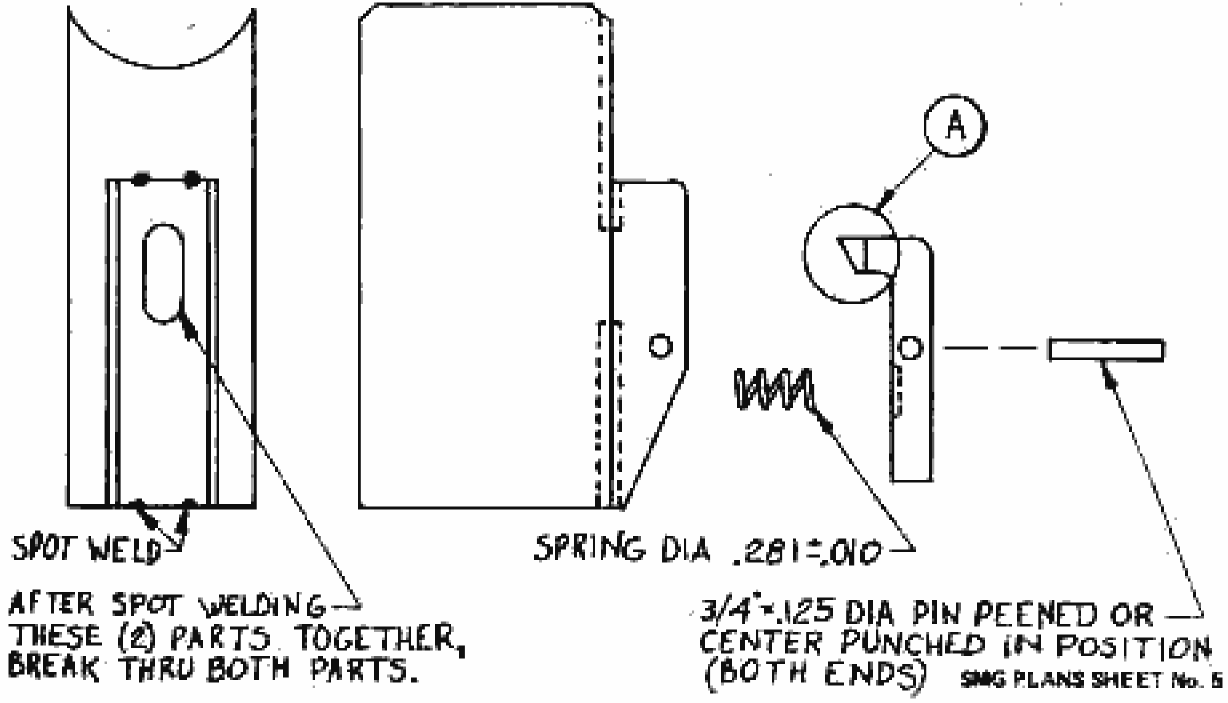

3/4"
1/2"
1/4" x 5/8" LONG, CUT THIS HOLE AFTER WELDING TO MAGAZINE PORT
1-7/8"
2.187±.015
.343
1/8" DIA THRU
1.095
1 3/16"

NOTE: CAN BE MADE FROM 3/4 x 3/4 SQ. TUBING

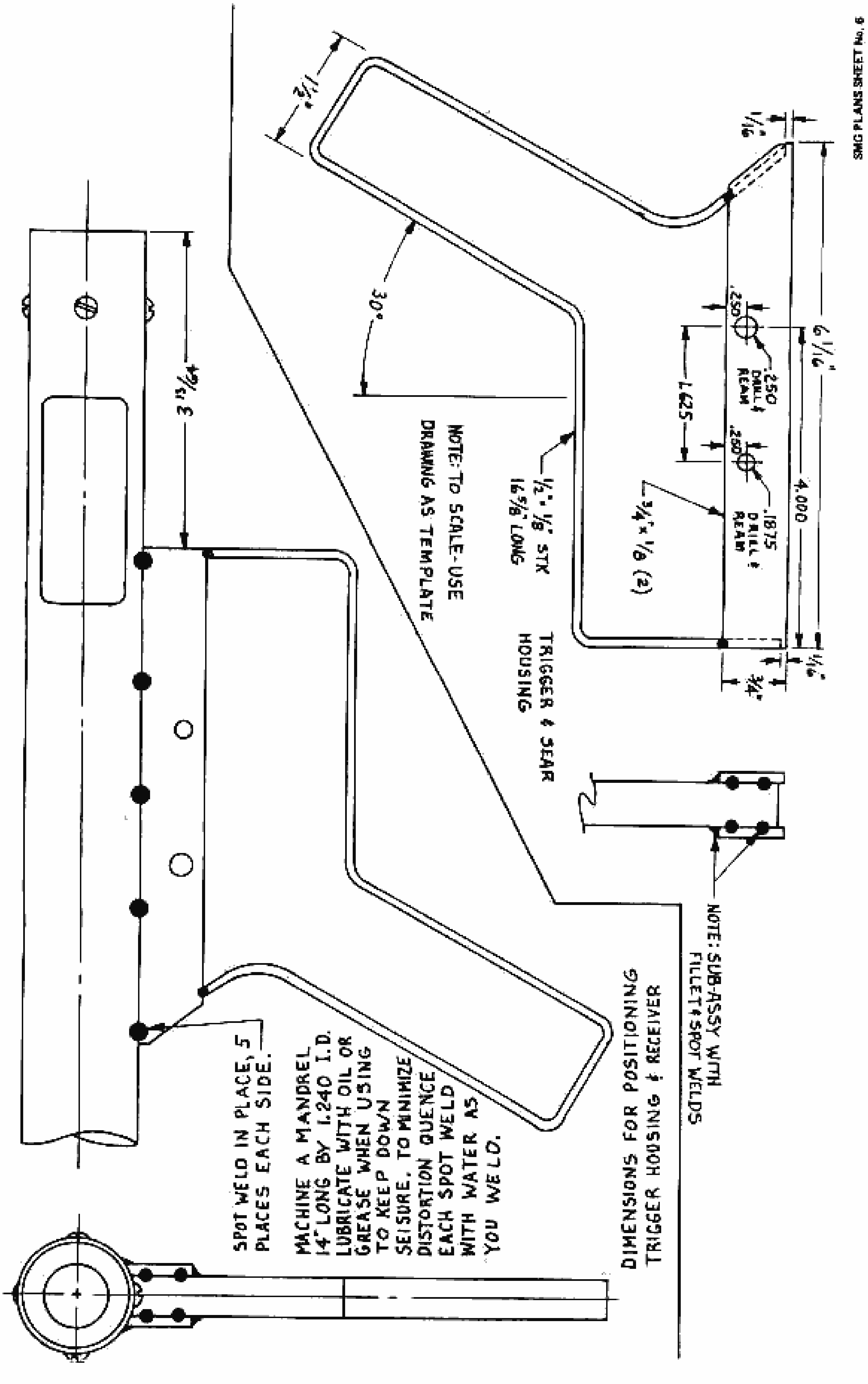

THIS EXTENSION TO BE .187 WIDE
1-41/64"
SPRING SEAT 5/16 DIA x 1/16 DEEP
.600
5/8"
.700±.005
.640
.250
1/8" DIA THRU
SERRATE THIS AREA

ASSEMBLY OF MAGAZINE HOUSING & MAGAZINE RELEASE

Ⓐ IT PROBABLY WILL BE NECESSARY TO DO SOME ADJUSTING OR HANDFITTING HERE TO GET THE PROPER FIT, AND AMOUNT OF ENGAGEMENT— BUT ONLY AFTER MAGAZINE HOUSING HAS BEEN WELDED TO HOUSING.


A
SPOT WELD
AFTER SPOT WELDING THESE (2) PARTS TOGETHER, BREAK THRU BOTH PARTS.
SPRING DIA .281±.010
3/4" x .125 DIA PIN PEENED OR CENTER PUNCHED IN POSITION (BOTH ENDS)

SMG PLANS SHEET No. 5


1/2"
30°
1/16"
6 1/16"
.250 DRILL & REAM
.250
.250
1.625
4.000
.1875 DRILL & REAM
3/4" x 1/8 (2)
3/4"
1/16"
1/2" • 1/8" STK 16 5/8" LONG
3 13/64
SMG PLANS SHEET No. 6

TRIGGER & SEAR HOUSING

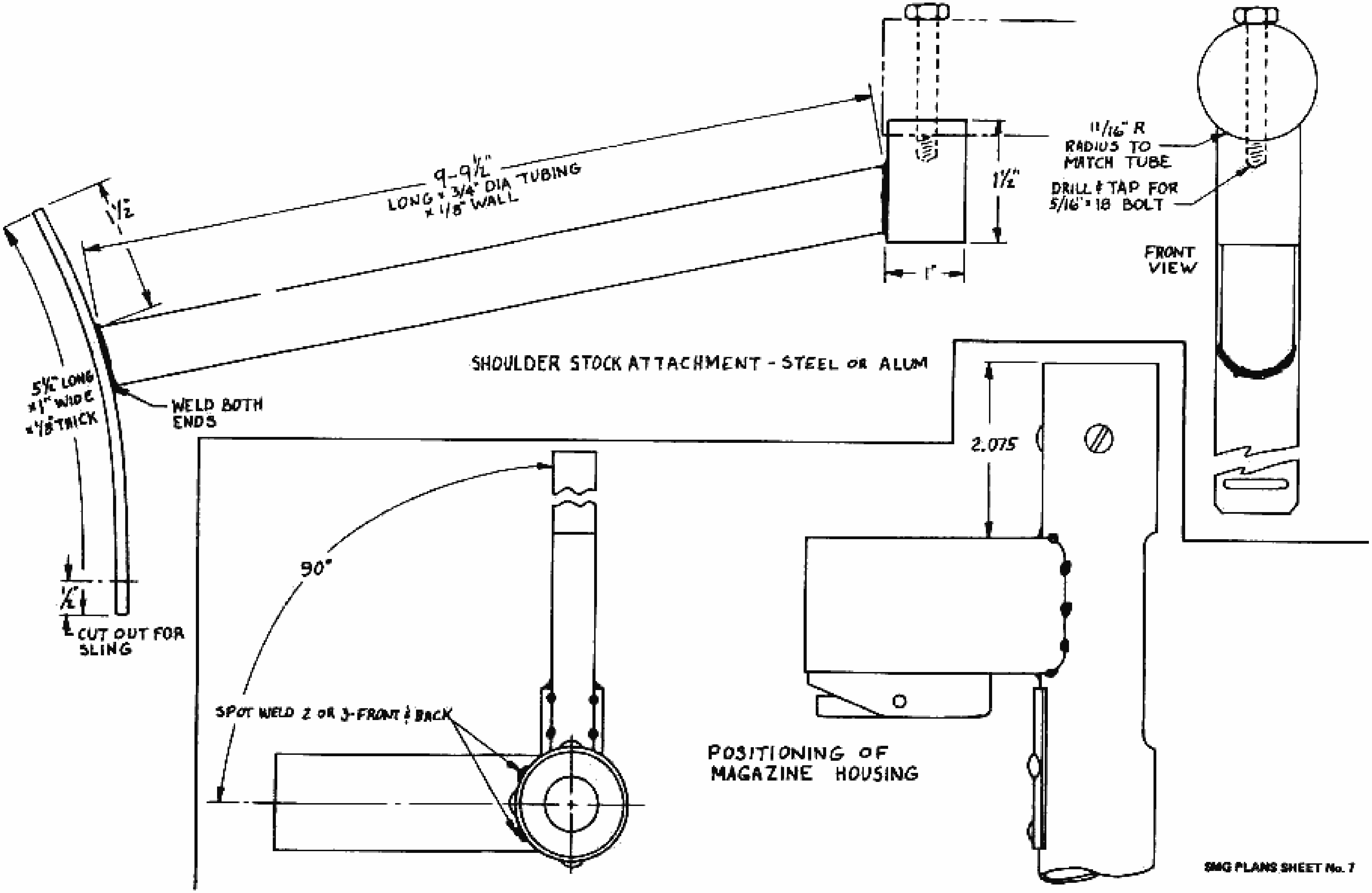
NOTE: TO SCALE-USE DRAWING AS TEMPLATE

NOTE: SUB-ASSY WITH FILLET & SPOT WELDS

DIMENSIONS FOR POSITIONING TRIGGER HOUSING & RECEIVER

SPOT WELD IN PLACE, 5 PLACES EACH SIDE.

MACHINE A MANDREL 14" LONG BY 1.240 I.D. LUBRICATE WITH OIL OR GREASE WHEN USING TO KEEP DOWN SEISURE. TO MINIMIZE DISTORTION QUENCE EACH SPOT WELD WITH WATER AS YOU WELD.



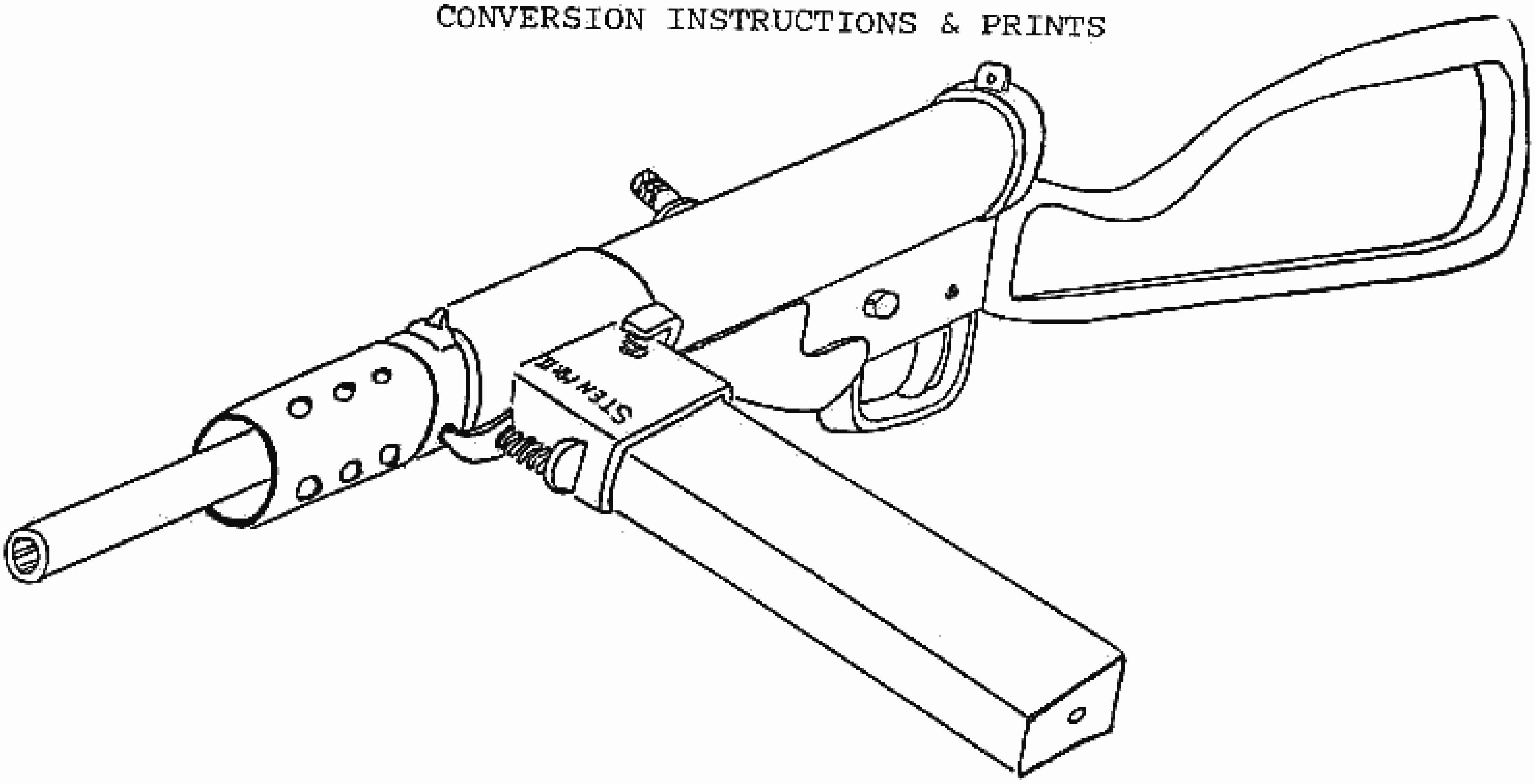
SHOULDER STOCK ATTACHMENT - STEEL OR ALUM

POSITIONING OF MAGAZINE HOUSING

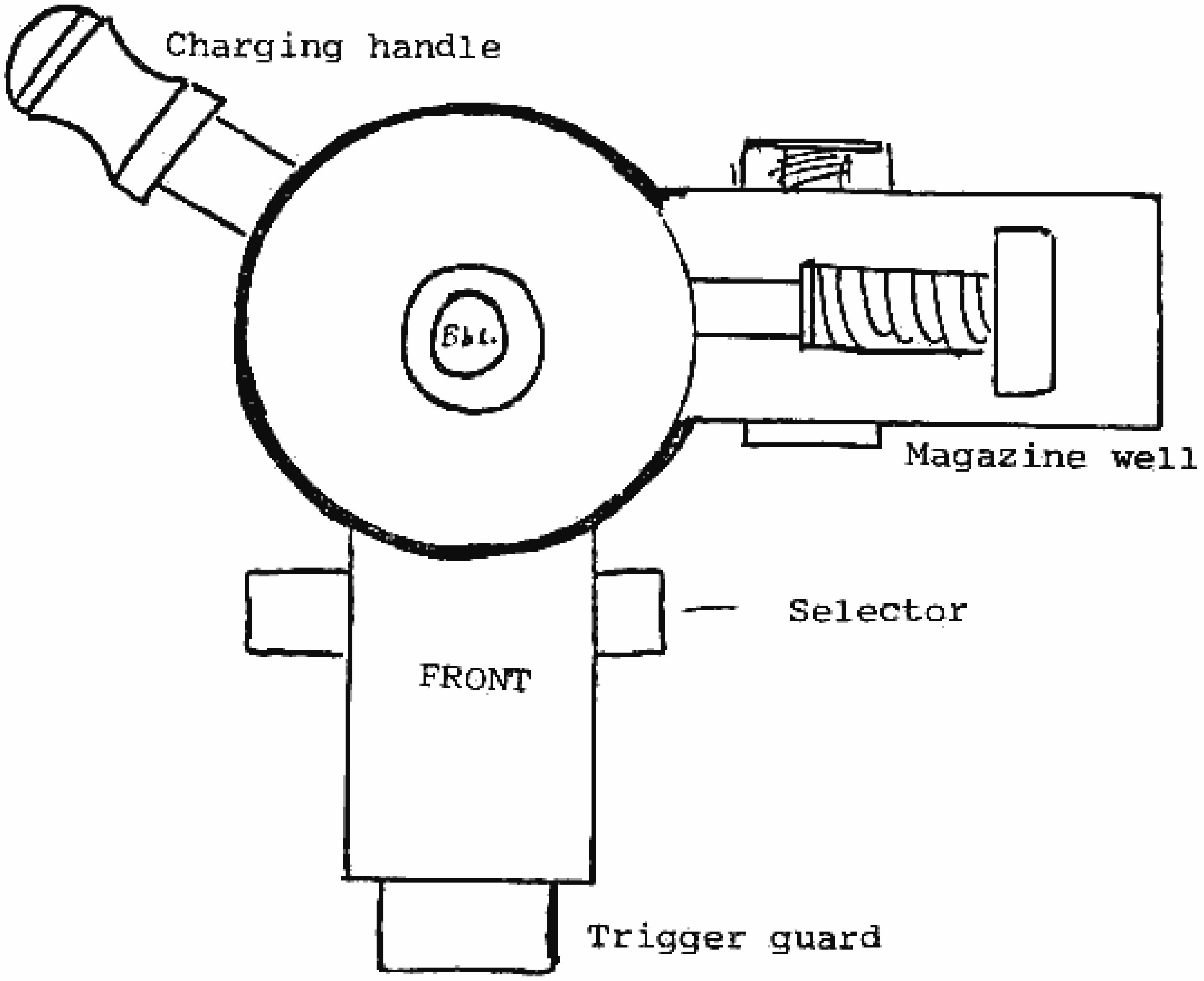
9-9½" LONG × 3/4" DIA TUBING × 1/8" WALL
1½"
1½"
1"
11/16" R RADIUS TO MATCH TUBE
DRILL & TAP FOR 5/16" × 18 BOLT
FRONT VIEW
5½" LONG × 1" WIDE × 1/8" THICK
WELD BOTH ENDS
½"
CUT OUT FOR SLING
90°
SPOT WELD 2 OR 3 - FRONT & BACK
2.075
SMG PLANS SHEET No. 7

STEN GUN MARK II

CONVERSION INSTRUCTIONS & PRINTS



Use a vertical mill or drill press if at all possible. Set up blank between centers and mill. Use a 1/4" end mill for all of the ports as they have a 1/8" radius on each corner. The charging handle slot is made


Charging handle
Bbl.
Magazine well
Selector
FRONT
Trigger guard

with a 3/8" end mill in all areas. Depending on your type of extractor, it gets a hole or slot in the area indicated in the magazine area. File to fit.

Due to the Sten being manufactured in many allied countries on various machinery, bolt diameters vary. Your bolt will most likely fit OK, but you may need to polish the tubes inside with an automobile brake cylinder hone and kerosene BEFORE cutting ports.

The end of the tube marked in yellow will get the barrel bushing.

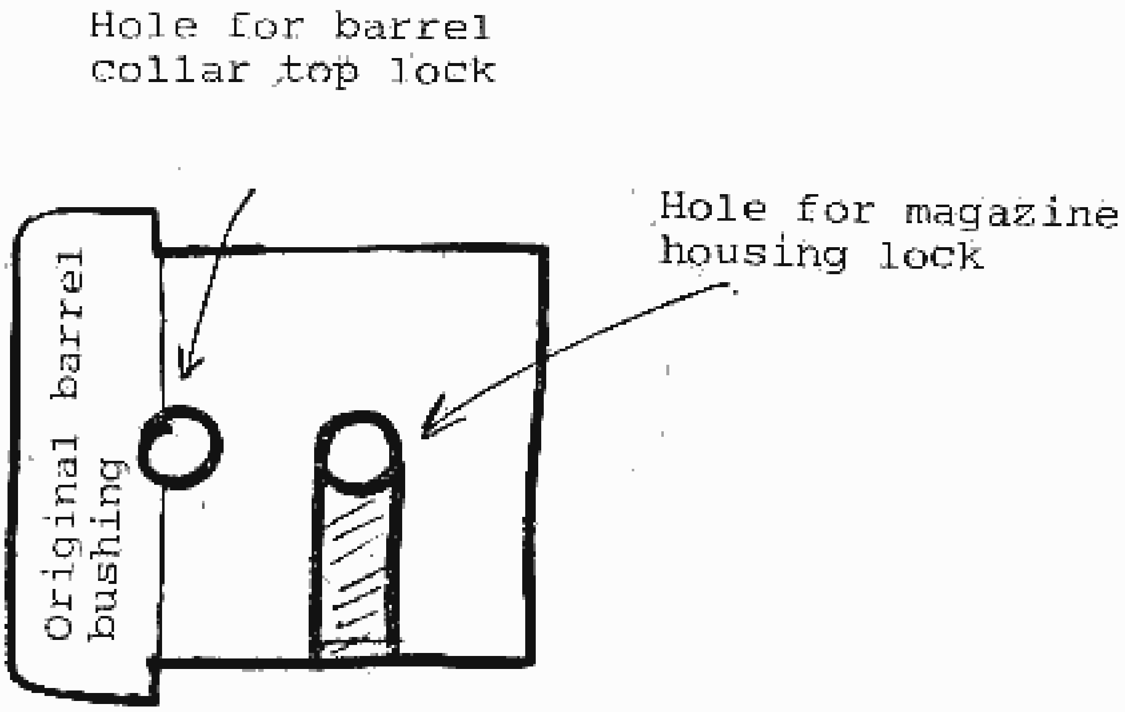
After assembly of the weapon, locate and drill a 1/4" hole for the barrel retaining lock. Check how the bushing goes in before welding it into place.

The ejector may have to be filed for proper fit. The bolt should be able to slide freely over the ejector while still being high enough to work properly. Test with an empty case or dummy round.

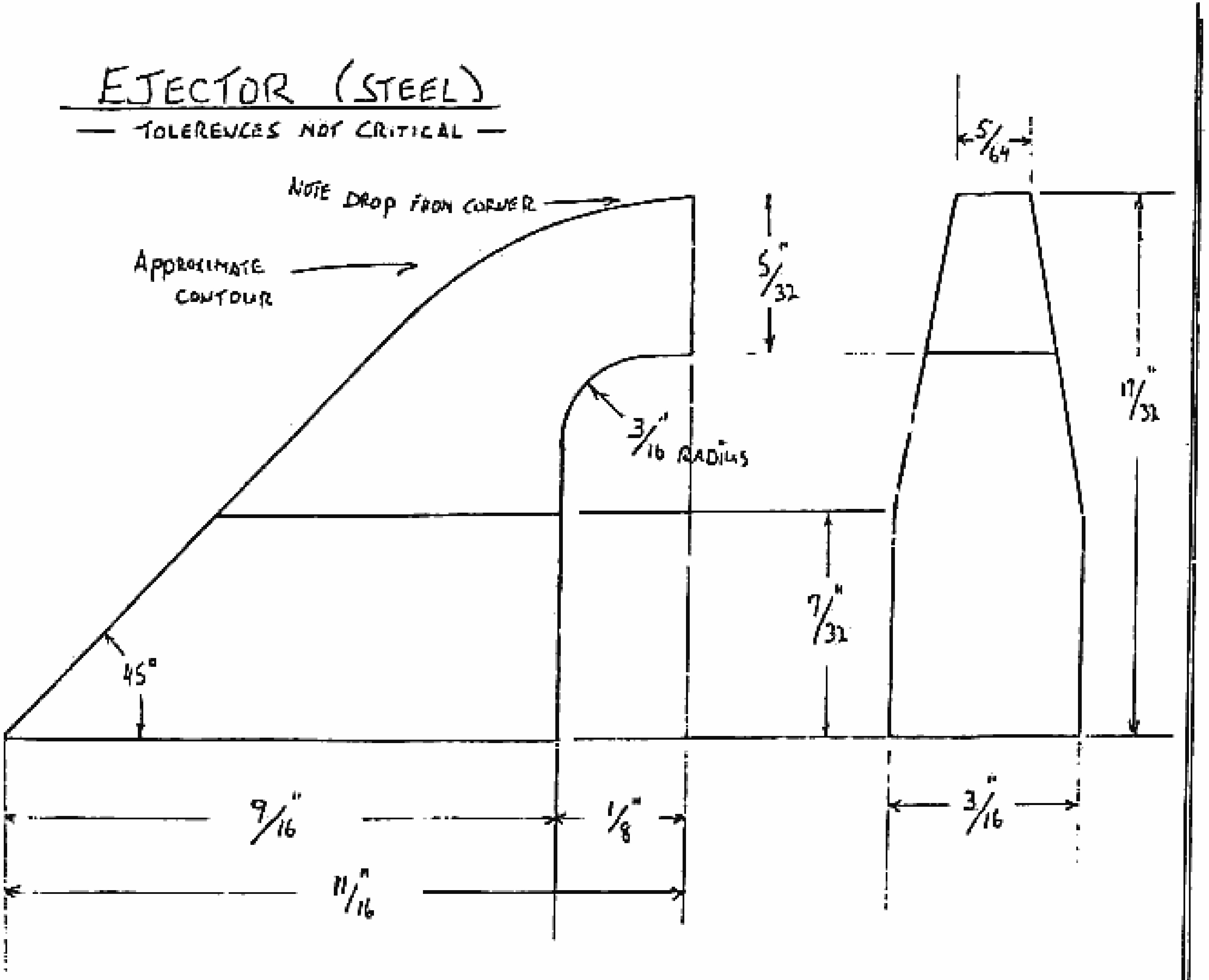
When welding the tube to the rear housing, place a snug fitting dowel through the housing into the tube to maintain the proper alignment of these two parts. The tabs on the trigger housing are welded to the tube. Weld the tube to the housing, THEN align the barrel bushing.

NOTE: It will probably be necessary to slightly enlarge the inside diameter of the magazine housing band where it slides over the tube. This is normal.

TIPS:
- Test with dummy rounds.
- Ejector is fitted just behind magazine port (see ejector page).
- Mount a front sight on the magazine housing. Otherwise, you won't be able to remove this housing if you have to.

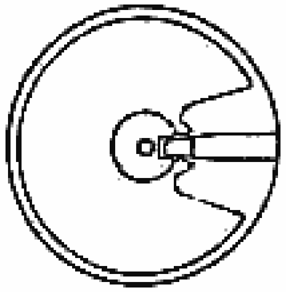

Hole for barrel collar top lock
Hole for magazine housing lock
Original barrel bushing

The two holes (1/4") in the barrel bushing shown here are to be drilled through the tubing and through the barrel bushing for the respective locking devices. Since the barrel bushings vary, it is best to measure yours. No measurement is given since they vary. The holes are best drilled after the bushing is welded in place. Ejectors vary also, but the ejector page should be of help.


EJECTOR (STEEL)
— TOLERENCES NOT CRITICAL —
NOTE DROP FROM CORNER
APPROXIMATE CONTOUR
3/16" RADIUS
45°
5/32"
7/32"
9/16"
1/8"
11/16"
5/64
17/32"
3/16"

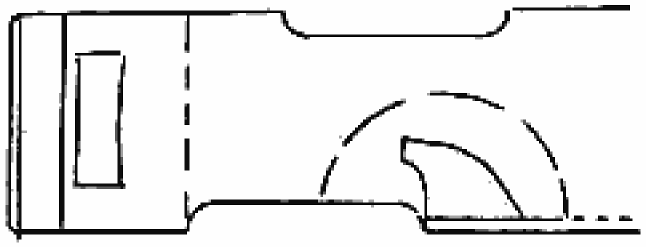
FRONT VIEW

SHOWING EJECTORS RELATION TO BOLT



TOP VIEW

CUT-A-WAY SHOWING POSITION OF EJECTOR

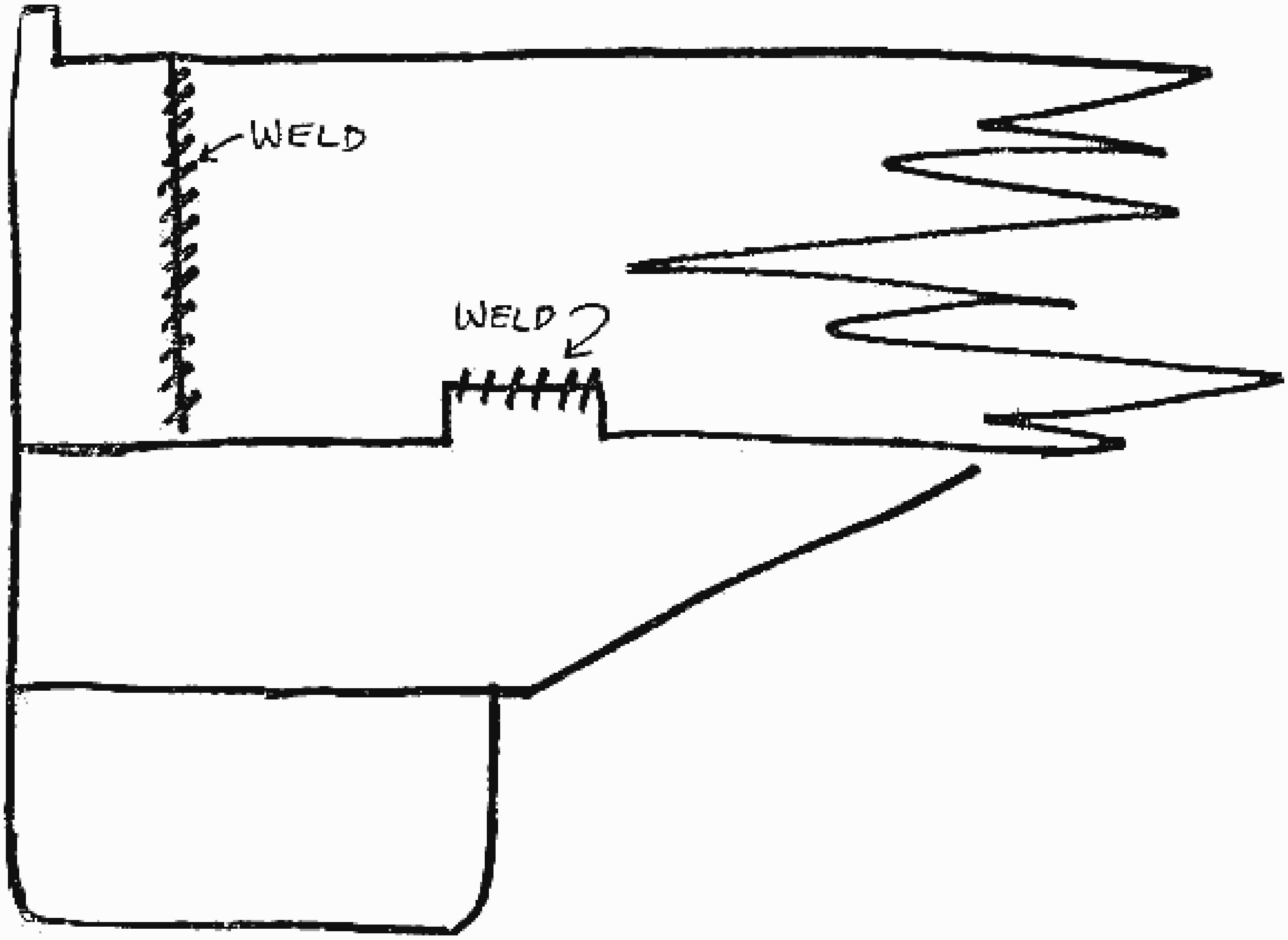


THE EJECTOR IS SHOWN HERE FOR THOSE WHO DON'T HAVE ONE. IT IS EASY TO MAKE.

This is your rear cut.

Locate the magazine port. (Left Side). Measure forward from the front edge of this port, 1.078". This is your front cut. Actually, the size of the ejection (right side) is arbitrary. You may wish to change the shape of this port to suit your taste.

Remember! The charging handle slot is rotated 25 degrees from horizontal.



IMPORTANT! As shown in the above diagram, the tube is butted up against the rear ring and welded. When stripping your parts kit, DO NOT REMOVE old piece of tube inside this ring. The tube part has two "Dog leg cuts" in it to retain the mainspring cap retainer. The tube measurements are generated from the front face of this ring forward.

SUPPLIMENTARY INSTRUCTIONS

Read all notes and instructions before proceeding.

Method #1 If you have access to a vertical milling machine, this is the easiest and best. Set up the receiver blank between centers or in a good mill vise and mill (being careful not to crush the O.D.). The ejection port, magazine well and trigger port all have a 1/8" radius in each corner - so use a 1/4" end mill. The cocking handle slot is 3/8" wide in all areas - so use a 1/4" end mill. The small hole behind the magazine port is for the ejector. Drill the hole 5/32". The two larger holes in front of the magazine port are for the magazine housing lock. Drill these holes 1/4". (The furthest forward is for the barrel lock).

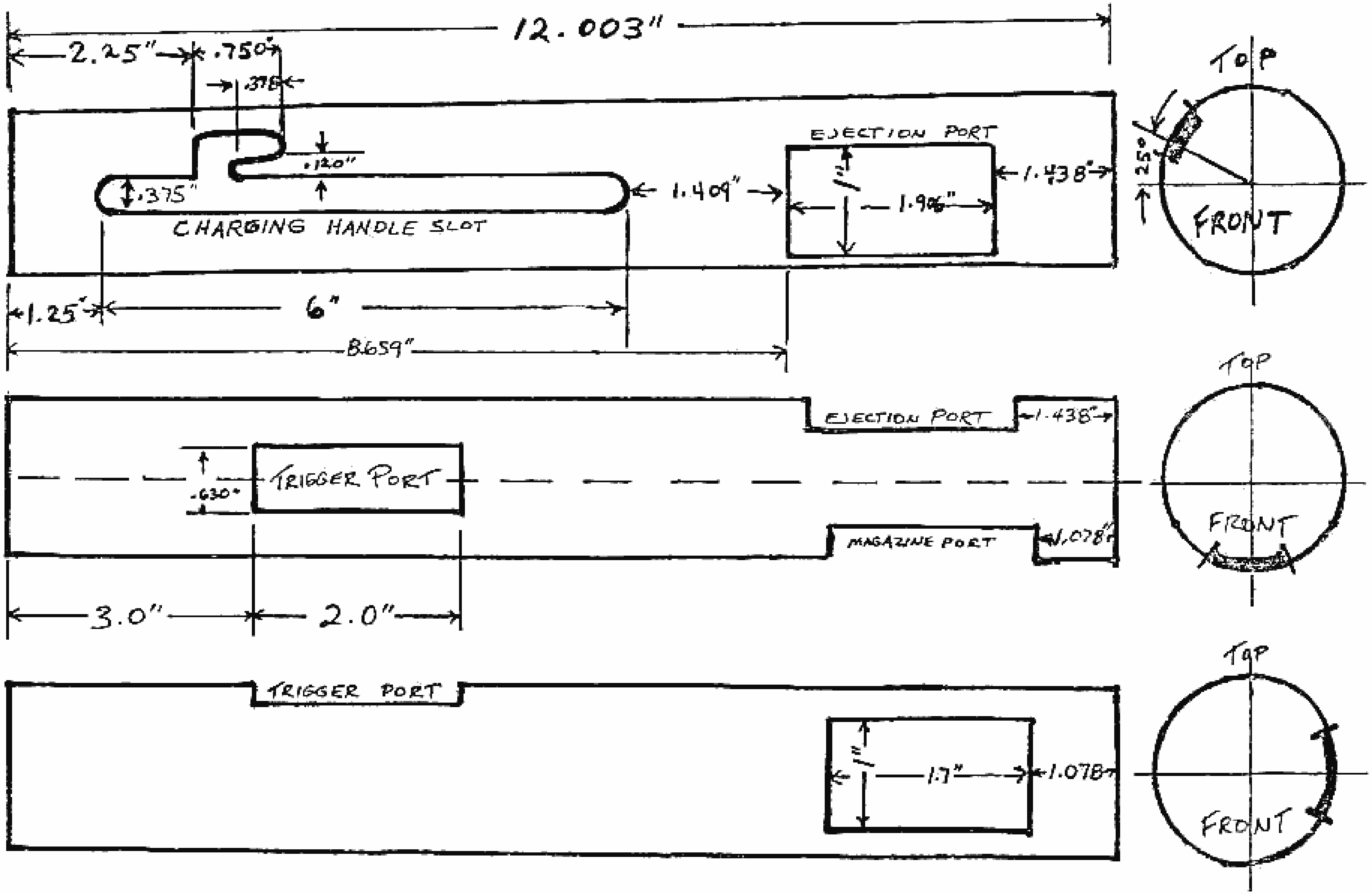
Method #2 To complete with a hand drill and file or Dremel style Moto-Tool (using cut-off disks). Place receiver blank in a vise, being careful not to crush the tube. Then, take a center punch and mark it for a 1/4" drill in each corner of the ports and ends of the slot.

Drill out the corners of the blacked in areas first, then drill more holes inside the blacked in areas to remove the metal along the straight edges(being careful to stay inside the black areas). Drill all the small holes as in method #1.

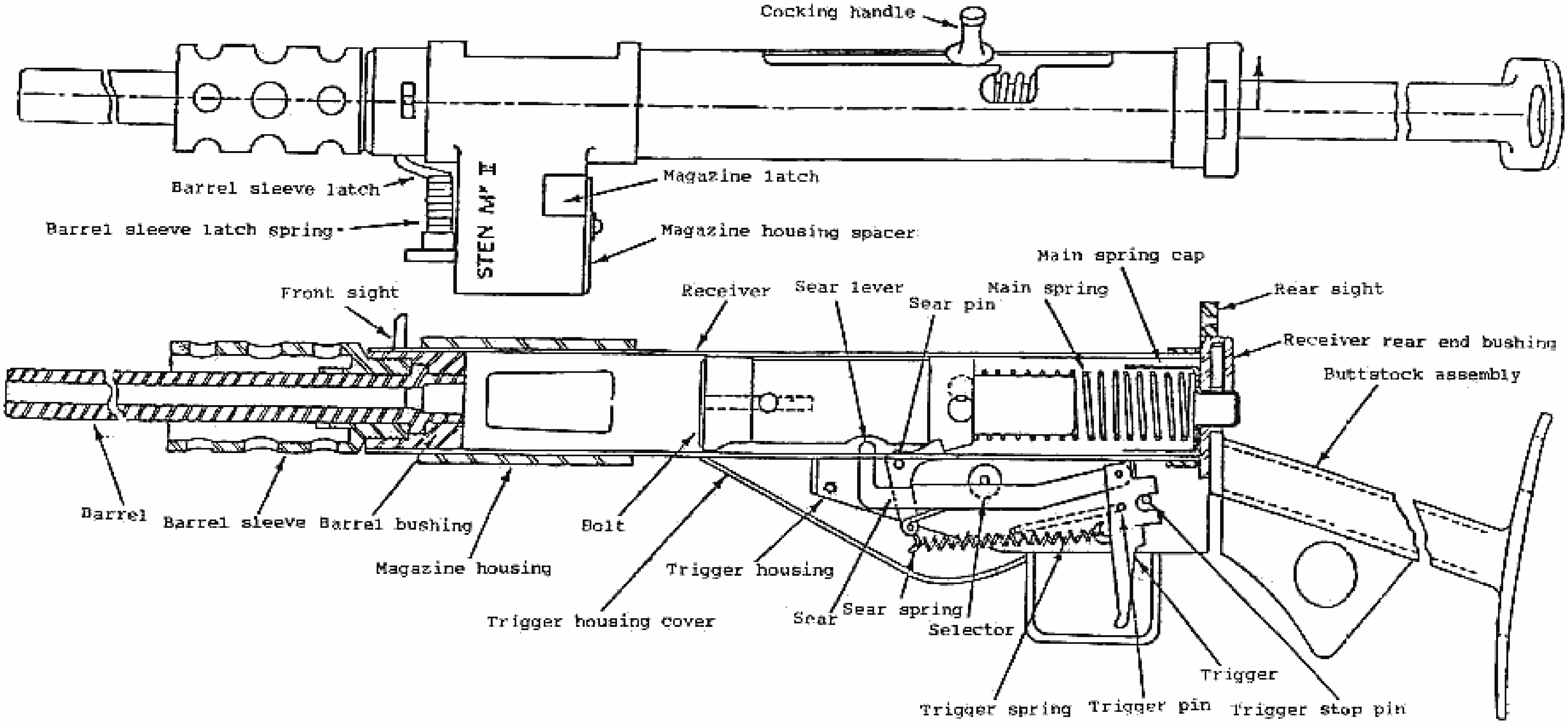
NOTES:

1. The barrel bushing must be turned down by lathe to an outside diameter of 1.398" - 1.400" (slip fit into tube). The best method is to turn the barrel bushing between centers for a concentric cut. DO NOT REMOVE ANY PART OF THE OLD TUBING THAT MAY BE ATTACHED TO THE BARREL BUSHING EXCEPT BY TURNING IT DOWN IN A LATHE OR IT MAY BE UNDERSIZE. THE INSIDE DIAMETER OF THE NEW TUBING IS A FEW THOUSANTHS OF AN INCH LARGER THAN THE ORIGINALS (modern stock sizes). The barrel bushing should be 1.5" long. Slide the barrel bushing into the front of the receiver tubing until flush and silver-braze, spot-weld or button-weld into place.
2. The ejector fits into the hole behind the magazine port. It should be silver-brazed in place. Filing the top of the ejector may be required to get a proper fit. The bolt must be able to just slide freely over the top of the ejector. Test with an empty cartridge case. When the action is worked rapidly, the case should be thrown clear of the action.
3. The trigger group and rear housing should be welded onto the receiver tubing.
4. The magazine housing may require some material removed from the interior diameter to allow it to slide freely over the receiver when assembling the gun.
5. After the barrel bushing is welded in place, the furthest forward hole should be drilled completely through on one side to allow the barrel lock to contact the serrations on the barrel. The hole drilled previously in the receiver tubing acts as a guide for this step.

CAUTION: This gun fires from an open bolt. Never close the bolt on a live round or the gun will fire.


12.003"
2.25"
.750"
.375
.120"
.375"
CHARGING HANDLE SLOT
1.409"
EJECTION PORT
1"
1.906"
1.438"
25°
TOP
FRONT
1.25"
6"
8.659"
TOP
EJECTION PORT
1.438"
TRIGGER PORT
.630"
MAGAZINE PORT
1.078"
FRONT
3.0"
2.0"
TRIGGER PORT
TOP
1"
1.7"
1.078
FRONT

This diagram is intended for use with ORIGINAL barrel bushing. It is pressed in the front and heliarc-welded. This diagram was prepared from an actual uncut Sten and also Austen.


Cocking handle
Barrel sleeve latch
Barrel sleeve latch spring
STEN Mk II
Magazine latch
Magazine housing spacer
Main spring cap
Front sight
Receiver
Sear lever
Sear pin
Main spring
Rear sight
Receiver rear end bushing
Buttstock assembly
Barrel
Barrel sleeve
Barrel bushing
Bolt
Magazine housing
Trigger housing
Trigger housing cover
Sear
Sear spring
Selector
Trigger
Trigger spring
Trigger pin
Trigger stop pin

SULPH
ACI
LACK
WDER

FIREWORKS & EXPLOSIVES LIKE GRANDDAD USED TO MAKE

CONTENTS

THE SCIENTIFIC AMERICAN CYCLOPEDIA 1903 142
DICK'S ENCYCLOPEDIA OF FORMULAS & PROCESSES 1872 ....(INDEX 167) 158
THE TECHNO-CHEMICAL RECEIPT BOOK 1896 (INDEX 187) 168
HENLEY'S TWENTIETH CENTURY FORMULAS 1907 188

NOTE

Many of the chemical terms in this book are so outdated you may not understand them. If you don't already have GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY, get one. It has a dictionary of over 2500 definitions and synonyms of vague and old-fashioned terms for chemicals, plants, processes, etc.

It also details the 19th Century methods of home manufacturing of most chemicals and substances you will need, from simple, easy to get raw materials.

GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY can be bought from Atlan Formularies and other dealers for $22.00

INTRODUCTION

Dick's Encyclopedia of Practical Recipes and Processes was first published in 1872. It details methods for making everything from deadly poisons to high explosives, narcotics, shoe polish, all the most popular patent medicines of the day and ketchup.

When that book was published, most of those who would misuse its information were in prisons or nuthouses. The rational, lawabiding person was trusted with no end of potentially dangerous materials. He was also trusted to teach his children the dangers of anything they were permitted to use, such as fireworks. His children were trusted, not only in playing with the fireworks safely, but they were also trusted not to cause damage to property or to other children.

There were very few injuries; less than kids got from falling out of their neighbor's apple trees.

Since the governors trusted the people, the people accepted the responsibility imposed by that trust. In the same sense, the children accepted the responsibility imposed by their parents' trust.

As more people were born into our society who were mentally defective, or just naturally stupid and irresponsible, many wonderful things were made illegal. In 1934 firearm silencers were outlawed. As one of the noisiest children in Brooklyn, I didn't miss silencers. At the same time, automatic weapons were also outlawed. I didn't know about that. I took it for granted that as soon as I got bigger I would own a Tommygun.

When I was seven I remember buying firecrackers for five cents for a packet of 20. I liked to put them under tin cans. Often I would spend hours building elaborate fortifications for my toy soldiers just so I could blow them all up.

I never suffered an injury worse than a flash-burn. I never knew anyone who had been seriously hurt. When anyone was damaged the tale was passed around and elaborated on but such stories just served to make the rest of us more careful.

Later, in Chicago, I remember firecrackers were made illegal. This shot the price up to 20c for a packet of 20. The torch of Al Capone was passed down to teeny-bopper gangsters and there seemed to be more firecrackers sold illegally than had been sold when they were legal.

Then there were injuries aplenty. Many people were hurt when packs of firecrackers were set off in crowded streetcars or elevators. Since firecrackers were illegal there was no instruction or parental guidance. Also, since the normal, open, use of firecrackers was out of the question, their abnormal and destructive use was the rule of the day.

Today, the average fire marshal is dedicated to removing all fireworks from our society. I agree with most of their arguments. Fireworks *are* unsafe when used only by those who have no respect for the law.

But since the main harm is caused by the irresponsible and dimwitted in our society, then those elements must be suppressed, not the rational ones. I'm just selfish enough to want the moron or the psychotic to be confined if his freedom takes away mine. If he is not to be trusted with fireworks, guns, etc., then let him be put in a nice place where attendants or guards can control the traffic in potentially dangerous things.

Do we live in a nation-wide mental institution, where the police officer is supposed to function as a nuthouse attendant, seeing that none of us have anything sharp, lest a real sickie hurt someone? To Hell with that!

Alcoholics, improvident and violent drunks, spurred the adoption of Prohibition. This took away the freedom of the responsible social drinker and built a criminal class which is still a fixture decades after Prohibition has ended.

So enough of editorializing. When the Law comes to its senses, or is made ineffective by just too many boobs, you will be free to play with potentially dangerous materials to your heart's content.

Even if you are responsible and intelligent, knowledge of the materials and processes is necessary to avoid injuries. Such knowledge is now pretty much limited to professionals who use such technical methods and machinery that the layman is effectively barred from their field.

However, Granddad made just as good stuff with simple hand tools and such. So, since you have this book, you should be pretty safe.

You must realize that Granddad learned from the ground up and had a thorough understanding of his materials. You ought to look up each chemical and study its specific hazards, flashpoint, etc., before pulverizing it or mixing it with other chemicals.

Always wear goggles when working with any quantity of potentially explosive material. Even a small accident can blind you. If you are not blinded, particles of matter in the eyeballs can cause agony for months. Simple goggles prevent this.

Leather gloves are useful, also, to prevent flash burns, which can be severe. The hand protectors described on page 48 are required when working with materials like potassium chlorate or other explosive substances.

When following these formulas it is suggested you make your own chemicals as shown in GRANDDAD'S WONDERFUL BOOK OF CHEMISTRY, $22 from Atlan Formularies.

Modern chemicals have a greater purity and so would probably be a lot more powerful than those described in this book. This could cause your fireworks to be far more powerful than you want or expect them to be, thus leading to a lack of control, which is a danger in itself.

KURT SAXON MAY, 1975

The Scientific American Cyclopedia 1903

Pyrotechny. — *Asteroid Rocket.* — Composition for 1 lb.: Niter, 8 oz.; fine charcoal, 3½ oz.; No. 2 charcoal, ½ oz.; sulphur, 2 oz.; meal powder, 1½ oz.

Bursting Powder.

Number	1	2	3
Meal powder	1	1	8
Grain powder F	—	1	—
Charcoal	—	—	1

Chlorate Meal Powder.

Number	1	2	3
Chlorate of potash	25	15	60
Charcoal, fine	5	3	9
Sulphur	3	2	8

To Represent Cordage in Fireworks.—Antimony, 1 part; juniper resin, 1 part; niter, 2 parts; sulphur, 16 parts. Mix and soak soft ropes with the composition.

Common and Sparkling Fires.—1. Meal powder, 4 parts; charcoal, 1 part.

2. Meal powder, 16 parts; niter, 8 parts; sulphur, 4 parts; charcoal, 4 parts.

3. Meal powder, 16 parts; very fine glass dust, 5 parts.

4. Meal powder, 8 parts; very finely powdered porcelain, 3 parts. These fires can be arranged very effectively as stars, suns, etc. For instance, provide a circular disk of hard wood, 6 in. in diameter and 1 in. thick. Nail to this 5 spokes of wood at equal distances from one another, and 15 in. long. Nail also to the back of the central disk a strip of wood about 2 feet long, 2 inches wide, and ¾ inch thick. By means of this you can screw the whole piece conveniently to your firing post. On each of the 5 spokes tie a case of brilliant fire, supported at its end, and connect the mouths of these with quick match.

Red Chinese Fire.—1. Meal powder, 16 parts; niter, 16 parts; sulphur, 4 parts; charcoal 4 parts; iron borings, 14 parts.

2. Meal powder, 16 parts; sulphur, 8 parts; charcoal, 3 parts; iron borings, 7 parts.

3. Meal powder, 8 parts; niter, 16 parts; sulphur, 3 parts; charcoal; 3 parts; iron borings, 8 parts.

4. Meal powder, 16 parts; niter, 8 parts; sulphur, 4 parts; charcoal, 3 parts; iron borings, 7 parts.

On Preparing Some Colored Fires (Bengal Lights) Used in Pyrotechny.—By Sergius Kern (St. Petersburg). — In preparing colored fires for fireworks by means of the usual formulæ given in many manuals of pyrotechny, it is often very necessary to know the quickness of burning of colored fires, as in some cases, as decorations and lances, they must burn slowly; in other cases, as wheels, stars for rockets, and Roman candles, they must burn quicker. Working for some months with many compositions of such kind, I prepared three tables of colored fires (red, green and violet), where every formula with a higher number burns quicker than a fire with a lower number. For instance, No. 5 burns quicker than No. 6 and slower than No. 4. These tables will, I think, be of much assistance in the preparation of fireworks.

Green Colored Fires.—

No.	Potassium Chlorate. Per cent.	Barium Nitrate. Per cent.	Sulphur. Per cent.
1	36	40	24
2	29	48	23
3	24	53	23
4	21	57	22
5	18	60	22
6	16	62	22
7	14	64	22
8	13	66	21
9	12	67	21
10	11	68	21
11	10	69	21
12	9·5	69·5	21
13	9	70	21
14	8·5	70·5	21
15	8	71	21

Red Colored Fires.—

No.	Potassium Chlorate. Per cent	Strontium Nitrate. Per cent.	Sulphur Per cent.	Carbon Powder. Per cent.
1	40	39	18	3
2	32	46	19	2
3	27	51	20	2
4	23	55	20	2
5	20	58	20·5	1·5
6	18	60	21	1
7	16	61 6	21 2	1·2
8	15	63	21	1
9	13	64	22	1
10	12	65	22	1
11	11	66	22	1
12	10	67	22	1
13	10	67 25	22	0·75
14	9·25	68	22	0·75
15	9	68·35	22	0·65

Violet Colored Fires.—

No.	Potassium Chlorate. Per cent.	Calcium Carbonate. Per cent.	Malachite powdered. Per cent	Sulphur. Per cent.
1	52	29	4	15
2	52	28	5	15
3	52	26	7	15
4	52	24	9	15

5	52	23	10	15
6	52	21	13	15
7	51	20	14	15
8	51	18	16	15
9	51	16	18	15
10	51	15	19	15
11	51	13	21	15
12	51	11	23	15
13	51	10	24	15
14	51	8	26	15
15	51	6	28	15

Colored Fires for Theaters.—We give below a table of the composition of the mixtures commonly employed for colored fires in tableaux, etc. These fires, however, should never be used within doors, as the gaseous products of some of them are extremely poisonous. The lime light lanterns and lenses of suitably colored glass have now been generally substituted for these fires, and give much better results.

	1 Green	2 Red	3 Yellow	4 Blue	5 White
Chlorate of potash	32·7	29·7		54·5	
Sulphur	9·8	17·2	23·6		20
Charcoal	5·2	1·7	3·8	18·1	
Nitrate of baryta	52·3				
Nitrate of strontia		45·7			
Nitrate of soda			9·8		
Ammonium sulphate of copper				27·4	
Saltpeter			62·8		60
Black sulphide of antimony		5·7			5
Floury gunpowder					15

It is hardly necessary to mention that great care is required in mixing these materials, and that each should be pulverized separately.

Fires or Lights, Colored.—These fires serve to illuminate; hence intensity of light with as little smoke as possible is aimed at. In the preparation of such mixtures the ingredients, which should be perfectly dry, must be reduced separately, by grinding in mortar or otherwise to very fine powders, and then thoroughly but carefully mixed together on sheets of paper with the hands or by means of cardboard or horn spatulas. The mixtures are best packed in capsules or tubes about 1 in. in diameter and from 6 to 12 in. long, made of stiff writing paper. Greater regularity in burning is secured by moistening the mixtures with a little whisky and packing them firmly down in the cases by means of a wooden cylinder, then drying. To facilitate ignition a small quantity of a powder composed of mealed powder, 16 parts; niter, 2 parts; sulphur, 1 part, and charcoal, 1 part, loosely twisted in thin paper, is inserted in the top. The tubes are best tied to sticks fastened in the ground.

White Lights.—

Saltpeter	4	oz.
Sulphur	1	oz.
Black sulphide of antimony	1	oz.

Yellow Lights.—

1. Chlorate of potash	4	oz.
Sulphide of antimony	2	oz.
Sulphur	2	oz.
Oxalate of soda	1	oz.
2. Saltpeter	140	oz.
Sulphur	45	oz.
Oxalate of soda	30	oz.
Lampblack	1	oz.

Green Lights.—

1. Chlorate of baryta	2	oz.
Nitrate of baryta	3	oz.
Sulphur	1	oz.
2. Chlorate of potash	20	oz.
Nitrate of baryta	21	oz.
Sulphur	11	oz.

Red Lights.—

Nitrate of strontia	25	oz.
Chlorate of potash	15	oz.
Sulphur	13	oz.
Black sulphide of antimony	4	oz.
Mastic	1	oz.

Pink Lights.—

Chlorate of potash	12	oz.
Saltpeter	5	oz.
Milk sugar	4	oz.
Lycopodium	1	oz.
Oxalate of strontia	1	oz.

Blue Lights.—

Chlorate of potash	3	oz.
Sulphur	1	oz.
Ammonio-sulphate of copper	1	oz.

For colored fires, where the mixtures are ignited in shallow pans and maintained by additions of the powders, the compositions are somewhat different.

White Fire.-

Niter	16	oz.
Mealed powder	4	oz.
Sulphur	8	oz.

Yellow Fire.—

Niter	2	oz.
Sulphur	4	oz.
Nitrate of soda	20	oz.
Lampblack	1	oz.

Red Fire.—

Niter	5	oz.
Sulphur	6	oz.
Nitrate of strontia	20	oz.

Lampblack	1	oz.

Blue Fire.—

Niter	8	oz.
Sulphur	2	oz.
Sulphate of copper	4	oz.

Green Fire.—

Niter	24	oz.
Sulphur	16	oz.
Nitrate of baryta	48	oz.
Lampblack	1	oz.

Bengal Fire.—

Sulphur	4	oz.
Mealed powder	4	oz.
Antimony	2	oz.
Lampblack	16	oz.

From the *Western Druggist*:

Red Fire.—

Strontium nitrate	3	parts.
Potassium chlorate	1	part.
Shellac, in coarse powder	1	part.

Mix.

Green Fire.—

Barium nitrate	3	parts.
Potassium chlorate	1	part.
Shellac	1	part.

Mix.

Violet Fire.—

Calcium carbonate	2	parts.
Malachite	2	parts.
Sulphur	2	parts.
Potassium chlorate	6	parts.

Mix.

Purple Fire.—

Copper sulphide	1	part.
Strontium nitrate	14	parts.
Calomel	14	parts.
Potassium chlorate	15	parts.
Shellac	5	parts.

Mix.

On account of the calomel, this must not be burned indoors.

Yellow Fire.—

Sodium nitrate	3	parts.
Potassium chlorate	1	part.
Shellac	1	part.

Mix.

Blue Fire.—

Copper ammonia sulphate	6	parts.
Potassium chlorate	1	part.
Shellac	1	part.

Mix.

Five-Pointed Star.

Number.	1	2
Meal powder	3	—
Sulphur	8	2
Niter	12	5
Sulphide of antimony	1	1

Spur Fire, for Flower Pots and Star Candles.

Number.	1	2	3	4	5	6	7
Vegetable black	7	2	3	4	2	4	3
Sulphur	14	5	4	16	6	9	7
Realgar, or sulphide of arsenic	2	1	1	2	1	1	1
Niter	32	16	10	32	11	20	15
Meal powder	—	3	—	17	4	5	4
Charcoal	—	—	—	4	1	1	1

Flower Pots, Composition for.—Niter, 18 parts; sulphur, 8 parts; lampblack, 6 parts.

Gerbe.

Number	1	2	3	4	5	6	7	8	9	10	11	12
Sulphur	2	3	—	1	—	2	3	2	2	2	—	—
Niter	2	2	—	—	—	10	6	4	9	4	—	—
Meal powder	16	36	4	8	16	—	9	16	2	2	8	3
Steel filings	1	6	—	—	—	—	—	—	—	—	—	—
Cast iron borings	5	8	1	3	8	7	5	8	5	3	—	—
Charcoal	—	—	—	—	1	2	2	1	2	2	—	—
Coke grains	—	—	—	—	—	—	—	—	—	—	1	—
Porcelain grains	—	—	—	—	—	—	—	—	—	—	—	1

The Mixture for Golden Rain is Composed of.—

Niter	16	oz.
Sulphur	11	oz.
Mealed powder	4	oz.
Lampblack	3	oz.
Flowers of zinc	1	oz.
Gum arabic	1	oz.

All the materials used in fireworks must be in the state of fine powders and perfectly dry.

Gunpowder.—The component parts of gunpowder are saltpeter, sulphur, and charcoal, used in the following proportions:

1. English war powder.—Saltpeter, 75 parts; sulphur, 10 parts; charcoal, 15 parts.
2. French war powder.—Saltpeter, 75 parts; sulphur, 12·5 parts; charcoal, 12·5 parts.
3. French sporting powder.—Saltpeter, 76·9 parts; sulphur, 9·6 parts; charcoal, 13·5 parts.
4. French blasting powder. — Saltpeter, 62.

parts; sulphur, 20 parts; charcoal, 18 parts.

There are a number of variations of the above receipts, but the difference, which is purely a matter of opinion, consists principally in varying the quantity of sulphur or charcoal employed.

Inflamant.

Number	1	2	3
Charcoal	1	1	1
Meal powder	8	16	24
F. F. F. grain	4	8	12

Lances.—1. Lances are small paper cases, two to four in. in diameter, filled with composition, and are used to mark the outlines of figures. They are attached endwise to light wooden frames or sticks of bamboo and connected by streamers or quick match. The following are some of the compositions used in these:

	White	Yellow	Red	Blue	Green
Niter	28	—	16	8	96
Sulphur	9	4	10	2	64
Mealed powder	5	4	7½	—	—
Nitrate of soda	—	16	—	—	—
Lampblack	—	2	—	—	8
Nitrate of strontia	—	—	30	—	—
Sulphate of copper	—	—	—	4	—
Nitrate of baryta	—	—	—	—	192

2. Lances are used in making up devices, such as names, mottoes, wreaths, and so on. They consist of small cases, generally made about 3/16 of an inch in diameter, that is, round a piece of glass or brass rod or tube of that size; tubes are always best for these small formers. The cases are about 2 or 2½ in. long, with one end pinched or turned in. Two rounds of thin demy or double crown white paper, pasted, will give sufficient thickness and substance for the case. The cases, when dry, are to be filled with either of the compositions in the same way as golden rain:

Compositions for Lances. White.—1. Niter, 16 parts; sulphur, 8 parts; meal powder, 6 parts.

2. Niter, 16 parts; sulphur, 4 parts; meal pow- 6 parts.

3. Niter, 12 parts; sulphur, 4 parts; sulphide of antimony, 3 parts.

4. Niter, 72 parts; sulphur, 18 parts; regulus of antimony, 33 parts; realgar, 1 part; shellac, 1 part.

5. Niter, 96 parts; sulphur, 24 parts; regulus of antimony, 48 parts; realgar, 6 parts; shellac, 1 part. These for the most part give a bluish white flame, and when employed in cases of the size mentioned above, burn slowly, and will last as long as this species of firework is required to last.

Yellow.—1. Chloride of potash, 72 parts; oxal. soda, 60 parts; stearine, 6 parts; sulphur, 6 parts.

Pin Wheels.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Sulphur	1	3	5	3	7	14	4	4	2	2	3	2	—
Niter	1	4	9	5	9	16	8	4	5	2	3	2	—
Meal powder	2	9	15	8	20	32	26	16	36	26	35	18	3
Sulphuret of Antimony	—	—	—	—	1	3	1	—	—	—	—	—	—
Beech sawdust, fine	—	—	—	—	—	—	1	—	—	—	—	—	—
Oxalic acid	—	—	—	—	—	—	—	3	—	—	—	—	—
Litharge, fine	—	—	—	—	—	—	—	—	2	—	—	—	—
Orpiment, or realgar	—	—	—	—	—	—	—	—	—	2	3	—	—
Vegetable black	—	—	—	—	—	—	—	—	—	1	2	—	—
Nitrate of lead	—	—	—	—	—	—	—	—	—	—	—	3	1

Compositions for Pin Wheels, etc.—

	Common.	Brilliant.	Chinese.	White.
Niter	6	1	1	6
Sulphur	1	1	1	7
Mealed powder	16	16	7	16
Charcoal	6	—	—	—
Steel filings	—	7	—	—
Cast iron filings	—	—	7	—

Port Fire.

Number	1	2	3	4
Meal powder	3	1	1	5
Sulphur	4	2	2	8
Niter	12	4	6	25

Quick Match.—Make a thick paste of gunpowder and hot water, with a small quantity of gum in it. Take about four strands of cotton, such as is sold in balls and used for making the wicks of lamps, steep this in the solution of niter used for making touch paper, and wring it as dry as possible; then rub it well in the gunpowder paste till it is thoroughly covered with it. One end of the cotton may be passed through a small funnel, whose mouth is not more than ⅛ in. in width. By this means, if the whole length of the cotton is drawn through it, the superfluous paste will be removed, and the match will be of a nice round form. Hang it out of doors on a dry day, and when it is nearly dry coil it upon a tray or paper, and dust it over with meal powder. In winter it will not be sufficiently dry for use under a week. When thoroughly dry it should be stiff and hard, and the less it is bent or doubled the better. To use this match for connecting the mouths of different fireworks, or clothing them, as it is termed, make some long paper tubes round a wire former which has a diameter of not less than 3/16 in. These pipes are threaded on the match, and have a piece cut away at their sides wherever they are inserted into the mouth of a case, in order that the match may be laid bare and convey its fire to the priming of the cases.

Silver Rain.

Number	1	2	3	4
Steel filings	1	2	2	3
Meal powder	4	7	8	—
Niter	—	1	—	2
Sulphur	—	—	1	—
Charcoal	—	—	—	3
Nitrute of lead	—	—	—	10

Gold Rain.

Number	1	2	3	4	5
Sulphur	1	1	1	—	—
Niter	2	2	2	—	—
Charcoal	6	1	5	1	3
Meal powder	16	6	18	4	8

Rockets, ½-lb.—Composition for.—1. Niter, 9 oz.; sulphur, 2 oz.; meal powder, 1½ oz.; fine charcoal, 2 oz.; No. 2 charcoal, 2 oz.

2. Niter, 8 oz.; sulphur, 2 oz.; meal powder, 1½ oz.; fine charcoal, 4 oz.

3. Niter, 8 oz.; sulphur, 1½ oz.; fine charcoal, 3 oz.; No. 2 charcoal, 1½ oz.

Rockets, ¼-lb.—Composition for.—1. Niter, 8 oz.; sulphur, 1½ oz.; meal powder, 2 oz.; fine charcoal, 2½ oz.; No. 2. charcoal, 1½ oz.

2. Niter, 8 oz.; sulphur, 1½ oz.; meal powder, 2½ oz.; fine charcoal, 2 oz.; No. 2 charcoal, 2 oz.

3. Fine fire.—Niter, 8 oz.; sulphur, 2 oz.; meal powder, 2½ oz.; fine charcoal, 4 oz.

Roman Candle.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sulphur	4	2	3	1	1	2	7	3	4	6	8	3	8	—
Charcoal	3	3	3	2	1	3	8	1	1	7	9	3	11	2
Niter	8	2	8	4	3	9	21	4	5	18	18	10	32	1
Meal p'wder.	8	8	3	3	2	4	12	5	4	4	4	7	—	3

Rockets.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sulphur	1	1	12	4	8	4	2	4	2	2	1	1	8	1	1	1	2	—
Charcoal	4	2	17	5	11	7	4	8	12	8	2	2	27	2	2	4	4	1
Niter	8	5	50	16	32	16	9	16	20	16	4	4	36	4	4	8	8	—
Meal powder	—	—	—	—	—	—	—	3	1	1	1	2	6	2	1	1	1	4
Steel filings	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	2	—	—

Roman Candles.—**To Make a ⅝ Roman Candle.**—Procure a straight piece of brass tube, ⅝ of an inch external diameter and 16½ inches long. Saw or file off a piece, 1½ inch long, Fig. 1. This is for the star former, and is drawn of the correct size.

In the other piece, of 15 inches, fix a handle, as shown, in diminutive, in Fig. 7. This is for the case former. It should be filed smooth at the end.

Take another piece of brass tube, 3/16 of an inch external diameter and about 16½ inches long. In this also fix a handle, or fix it into a handle, Fig. 4. Invert it, and set it upright in a flower pot, filled with sand or loose mould. Melt some lead in a ladle, and pour it slowly into the tube, leaving room for the air to escape up the side, till it is full. If the lead is poured in rapidly, the confined air, expanding, jerks the metal up, and may cause serious injury. A pound or more of lead will be required. When cold, drive the end of the lead in with a hammer, and file in smooth. This is for a rammer.

Take a piece of deal, Fig. 6, about 12 inches long, 6 inches broad, and ¾ inch thick; and, on the top, screw a handle, like one on a scrubing brush. This is for a rolling board. An iron door handle would answer. A wooden one, however, about an inch thick, not cylindrical, but slightly flat, and rounded at the edges, is preferable, as it gives more purchase for the hand.

Cut a piece of tin, or zinc, or thin board into the shape of figure 8, in which the distance between the arms, *a* and *b*, across the dotted line, shall be ⅞ of an inch. This is for a gauge, with which to measure the external diameter of the case. Write upon it, ⅞ space.

Procure some 60 lb., 70 lb. or 84 lb. imperial brown paper; the size of a sheet will be 29 in. by 22½. Cut a sheet into four equal parts, each 14½ by 11¼; paste the four pieces on one side, and lay them on one another, with the pasted face upward, putting the fourth piece with the pasted side downward, upon the pasted side of the third piece. Turn them over; take off the now top piece, and lay it flat on the near edge of a table, pasted side upward. Take the former, Fig. 7, and paste the tube all over. Lay it along the edge of the paper, bend the paper over with the fingers of both hands, and roll it tightly up, until the external diameter of the case about fits the guage, Fig. 8. If the paper should be too long, of course a piece must be cut off; if it should not be long enough, more must be added, taking care to bind in the second piece with three or four inches of the first piece; for if the whole of the first piece be rolled up before beginning the second, the latter, when dry, will probably slip off and spoil the case. The case having been rolled up, take the handle of the former in the left hand, lay the case flat on the near side of the table, take the rolling board, Fig. 6, in the right hand, press the front part of it on the case, and drive it forward five or six times, like a jack plane, letting the handle of the former slip round in the left hand. This will tighten the case, and render it, when dry, as hard as a book cover.

The former must always be pasted before rolling a case, to prevent its sticking. It should, likewise, be wiped clean with a damp sponge before being laid aside. Brass tubes keep clean a much longer time if lacquered. To lacquer them, clean them with very fine glass paper; make them hot by the fire, till you can just bear them on the back of the hand; then, with a camel's hair pencil, wash them over with thin lac solution. The cases may be either 14½ or 11¼ in. long; but 11¼ is the best, for when the cases are too long, the fuse, as it approaches the bottom, is apt, if slow, to smoke; if fierce, to set the top of the case in a flame. If the learner decides upon 11¼ in., the former and rammer may each be two or three inches shorter.

After the first case has been rolled up to fit the gauge, it may be unrolled and the paper measured. Future pieces of the same quire of paper can then be cut of the right size at once, so that the case will fit the gauge without further trouble.

A large slab of slate is convenient for rolling upon, but a smoothly planed board will answer every purpose.

When a number of cases are finished hitch a piece of flax two or three times round each of them, and hang them up to dry in a place free from draught, that they may not warp.

Flax is sold in balls; the thick yellow is the best. It is named indifferently, flax or hemp. It is much used by shoemakers and is sold at the leather shops. Two or three thicknesses of this, waxed, or drawn through the hand with a little paste, is very convenient for passing round the necks of small choked cases, tying cases on wheels, etc.

To Make a Roman Candle Star.—Take the former, Fig. 1, which, as said before, is 1½ in. long; have a cylindrical piece of turned wood, box, beech or mahogany, Fig. 2, about 2 in. long, and of a diameter to just fit easily into Fig. 1. At a point, *a*, at the distance of about ⅝ of an inch from the end, *d*, with a bradawl or very small gimlet or nosebit, make a hole and drive in a piece of brass wire, to project just so much as to prevent the tube slipping over it. A piece of a brass rivet, such as used by shoemakers, is convenient for the purpose. The part with the head on is best; a quarter of an inch length will be sufficient, filed or cut off with the nippers. It is evident that upon inserting Fig. 2 into the tube, Fig. 1, a vacant space of ⅝ of an inch will be left at the bottom. Fig. 3 is a piece of turned wood, or better still, of turned brass, exactly like Fig. 2, without the side pin, *a*. Now, to pump a star, insert Fig. 2 in Fig. 1; press the tube into damped composition, turn it round and withdraw it. Rest the tube on a flat surface, insert Fig. 3 and give it two or three taps with a small mallet, like Fig. 26. A convenient size for the mallet is 1⅛ in. square, 3 in. long, with a turned handle. The mallet is best made of beech or mahogany. The slight malleting consolidates the star and prevents it from getting broken in charging; it will compress it to about nine-sixteenths of an inch in height. Push it out and set it by to dry.

Stars are best made in summer, and dried in the sunshine; when dry they should be put into clean pickle bottles furnished with tight fitting bungs. A piece of wash leather passed over the bottom of the bung, gathered up round the sides, and tied at the top like a choke, makes a good stopper. Shot shaken up in bottles, with water, soon cleans them.

To Damp Stars.—Stars containing nitrate of strontium must be damped either with lac solution or wax solution; anything containing water destroys the color. Niter stars may be damped with gum water, dextrine solution or thin starch. Most other stars with either of the solutions. Crimsons and greens will mix with boiled linseed oil, but they cannot then be matched, as oil renders meal powder almost inflammable. With all stars, not a drop more of the solution should be used than is sufficient to make the composition bind; and it is advisable not to damp more than half an ounce at a time; this is particularly the case in using the lac solution, as it dries rapidly; and if a large quantity of composition is damped and gets dry and has to be damped over and over again, it becomes clogged with the shellac and the color is deteriorated. If it should get dry, and require a second damping, it is best to use pure alcohol only the second time.

Before mixing compositions, every article should be as fine as wheaten flour and perfectly dry. Nitrate of strontium, if purchased in the lump, should be set over the fire in a pipkin; it will soon begin to boil in its water of crystallization; it must be kept stirred with a piece of wood till the water is evaporated and a fine dry powder left. A pound of crystals will yield about eleven ounces of dry powder, which should be immediately bottled. Even then, if used in damp weather, it is best dried again and mixed with the other ingredients while warm. This second drying may be in a six inch circular frying pan.

Articles, separately, may be reduced to powder with the pestle in a mortar. See that it is wiped clean every time, as there is danger of ignition with chlorates and sulphides. When the articles are to be mixed, they may be put into the mortar and stirred together with a small sash tool. A ⅜ in. is a convenient size. The mixture must then be put into a sieve and shaken in the usual way; or it may be brushed through with the sash tool. Return it to the sieve and brush and shake through again. As it lies in a heap, level or smooth it with the blade of a table knife, or any straight edge: if thoroughly mixed, it will present a uniform color; if it appears darker in one part than in another, it must be sifted again. A sieve with a top and receiver is very desirable, as nearly all mixtures are either black or poisonous; the dust from star mixtures is very injurious to the lungs. If a top and receiver cannot be readily purchased, both may easily be constructed out of a sheet of millboard, fastened with a bradawl and waxed yellow flax, and neatly covered with paper.

Mixtures may be damped on a Dutch tile, a marble slab, or a slate without a frame. They may be stirred about with a dessert knife, pressed flat, and chopped, or minced, as it were, and again pressed flat.

To Make Lac Solution.—Put half an ounce of flake shellac into a tin pot, and pour upon it ¼ of a pt. or 5 oz. of methylated spirit; or preferably, a like quantity of wood naphtha. Let it stand for about a day, stirring it occasionally till dissolved. Then half fill a basin with boiling water, set the tin containing the lac in it and leave it till it boils and curdles. If the water does not remain hot long enough to make it boil, set it in a second basin of boiling water. As soon as it has curdled remove it, and when cold pour it into a vial and cork it. Spirit must never be boiled over a fire nor near one, as the vapor might inflame. Keep the pot, therefor, while in the hot water, at a distance from a fire or flame of a lamp or candle.

To Make Wax Solution.—Put into a vial ⅛ an oz. of white (bleached beeswax), pour upon it 5 oz. of mineral naphtha (coal or gas tar naphtha); keep it tightly corked.

To Make Stearine Solution. — Dissolve a piece of composite candle in mineral naphtha in the same way. Mineral naphtha must not be used near a candle or fire, as it gives off an inflammable vapor at less than 100° Fahrenheit.

To Make Gum Solution.—There is no better way of preparing this than simply to put cold water upon gum arabic, and let it stand till dissolved. If for sticking purposes, as much water as will just cover the gum will be sufficient; but, for making quick match, 1 oz. or 1¼ oz. of gum to a pint of water. If required in a hurry, put the gum into cold water, in a pipkin or tin saucepan, set it on the fire, make it boil, and keep stirring till dissolved. When cold, bottle and cork it.

To Make Dextrine Solution.—Take ½ an oz. of dextrine and 5 oz. or a ¼ pt. of cold water, put the dextrine into a cup or basin, add a little of the water, and mix it well with a teaspoon, rubbing it till all is dissolved; then add the remainder of the water, stir well together a second time, pour it into a vial and cork for use. Dextrine, wetted to the consistency of honey, may be used instead of thick gum arabic water for pasting. For this purpose it is advisable to keep either in a wide mouthed bottle, and to set the bottle in a gallipot containing a little water; the brush, a camel's hair pencil, or very small sash tool with one-third of the bristles cut away on each side, to render it flat, can then be kept in the water when not in use; this will prevent it, on the one hand, from becoming dry and hard; and, on the other, from getting clogged and swollen. It can be squeezed between the thumb and fingers when wanted for use. The flat gum brushes now sold, bound with tin, are not pleasant to use, as the tin oxidizes and turns of a disagreeable brown color. If there is a difficulty in obtaining a graduated water measure, one sufficiently correct for pyrotechnic purposes may be made with a vial. Paste a narrow strip of paper up the outside of the vial, weigh 4 oz. of water in a cup in the scales; pour it into the vial, mark the height, and divide it into four equal parts for ounces; of course, it can be graduated into half and quarter ounces, and increased, if large enough, to five or more ounces. A gallon of distilled water weighs exactly ten pounds. Consequently a pint of pure water weighs a pound and a quarter. This is also near enough for spirit, though, of course, spirit is a trifle lighter. Doctors' vials are often marked with ounce divisions.

To Make Paste.—Paste is most economically made in a zinc pot, which may be 4 in. deep and 3½ in. diameter. Any zinc worker will make one to order. Put into it 2 oz. wheaten flour, add a little cold water, rub the two together with a spoon till smooth and free from lumps; pour in more water till the pot is full within about an inch, set the pot in half a saucepanful of water, put it on the fire; make the water boil, and keep it and the paste boiling for four or five minutes, stirring the paste the while. Remove it from the fire, and set it by to cool. The paste is to remain in the zinc pot, in which it will keep good for a length of time and beautifully white.

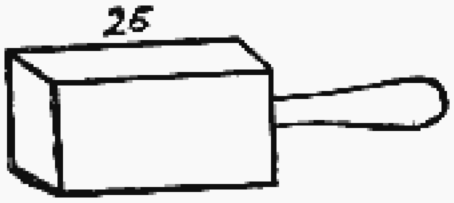
Some recommend alum in paste; but it is best avoided, especially in cases intended to receive colored fires. Alum is a double salt, a sulphate of alumina and potassa; it has an acid reaction; and, coming in contact with chlorate of potash and sulphur, may cause spontaneous combustion. A drop of sulphuric acid instantly ignites stars containing them. At theaters the clown sometimes fires a cannon with what appears to be a red hot poker, but which in reality is only a piece of wood painted red. A mixture is made of chlorate of potash and sulphur or sugar, a glass bead is filled with sulphuric acid, and the hole stopped up with wax. This is laid in the mixture, and when it is struck with the poker, the liquor escapes and inflames the potash and sulphur. Sulphate of copper is a particularly dangerous salt, and must never be used, as it is almost certain to cause spontaneous combustion. Chertier, to whom pyrotechny otherwise owes so much, introduced an empirical preparation, by dissolving sulphate of copper in water, together with chlorate of potash, drying it, and wetting it with ammonia; but this, however dried, when again wetted, turns litmus paper red. Practicus has named it Chertier's copper. Its use is not recommended.

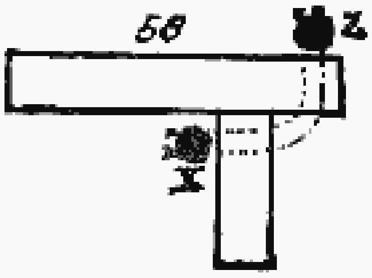
Two paste brushes will be sufficient for an amateur, sash tools, one about an inch diameter, the other smaller for light purposes. Let them stand in the paste. If they get dry, the bristles fall out. For convenience, one may be kept in the paste and one in water.

Dry clay, powdered and sifted as fine as possible, is used for plugging or stopping up the bottoms of cases. Amateurs have discontinued its use, and employ plaster of Paris in preference. Directions will be given for each, so that the learner can adopt which he pleases; but plaster is infinitely preferable. It is an American improvement.

Roman Candle Scoops.—No species of fireworks require greater care in their construction than Roman candles. In the first place the stars must be fierce, that they may light thoroughly; next, they must not be driven out with too great velocity. For this purpose the blowing powder must be carefully adjusted. The stars also must be of so easy a fit that when put into the case they may fall to the proper depth of their own accord. If they require pushing, they are too tight, and will probably be blown out blind. When made as directed they will necessarily be of an easy fit, as they will be of the inner diameter of the brass tube, while the bore of the case is equal to its external diameter.

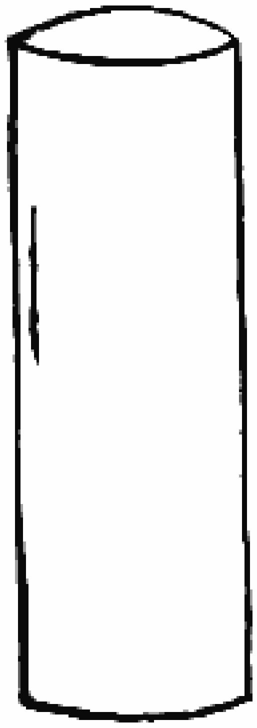
To regulate the blowing powder, prepare a number of little scoops, like Fig. 5, which is about the right size for the bottom star. They are formed of pieces of tin, zinc, or copper. Cut a long strip of tin ½ in. broad; cut this across into 7 pieces of the following lengths: 1⅝, 1¾, 1⅞, 2, 2⅛, 2¼, and 4 in. Round off the corners. Take a piece of brass wire, or stair rod, about ¼ in. in diameter, and with the wooden mallet before mentioned, Fig. 26, bend each of the pieces round the rod into a half cylinder or gutter. Take up the smallest and hold ⅝ in. of the end of the stair rod in the end of the semi-cylinder to keep it open; put the other part, from *a* to *b*, Fig. 5, in a vise and pinch it up; it will assume the form represented; the bowl part will be ⅝ in. long and the handle 1 in. long. Make the bowl of the next scoop ¾ in. long, the next ⅞ in.. and so on; the handle will always be 1 in. long. The last, for the top star, will have a bowl of 3 in. The smallest scoop ought to hold as much grain powder as will weigh about one twelfth of the star; but to have the scoops accurate, it will be necessary to charge a Roman candle, fire it, and observe whether the stars go a uniform height. For measuring the interval fuse, or fuse between the top of one star and the bottom of the next, a large scoop of the size of Fig. 10 will be required. The tin may be 1 in. broad, and the bowl part 2⅛ in. long, bent round the rammer, Fig. 4. To adjust it, take a Roman candle case, fit on the foot, Fig. 9, which is a piece of wood or brass turned with a tenon to fit tight at the bottom of the case. Fill the scoop and strike it level with a straight edge; empty it into the case, rest the foot on a flat surface; insert the rammer, Fig. 4, and jolt it up and down a dozen times or more, lift it about ½ in. at a time; put in another scoopful and jolt it in like manner. If the two scoopfuls thus compressed fill 1 in. of the case, the scoop will be correct. If more or less, the scoop must be shortened or lengthened accordingly.

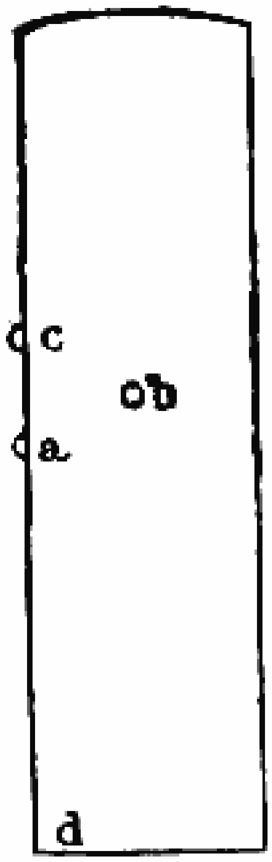




A piece of writing paper may be pasted and wound twice round the handle of each scoop, as from *a* to *b*, Fig. 4. One dot can be put upon the scoop for the first or bottom star; two dots for the second scoop, etc., or any memorandum can be written upon them for future guidance. Should they get soiled, they may be cleaned with a soaped damp piece of sponge.

Gunpowder for fireworks is used in two forms, meal powder and grain powder. Meal powder is a fine black dust and is employed in all cases of mixing. Grain powder is of three kinds, F, FF, and FFF—fine, double fine and treble fine. FFF is best for crackers, simply because it runs rapidly down the pipes; for driving stars, shells, etc., F will be sufficient but FFF may be employed; FF need not be purchased. If in any place there should be a difficulty in obtaining meal powder, F grain





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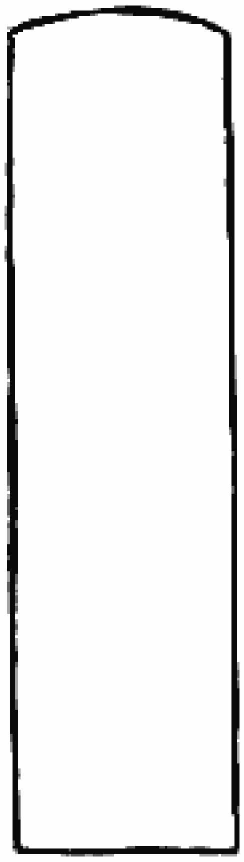

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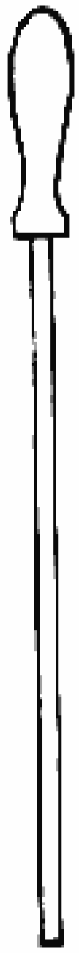

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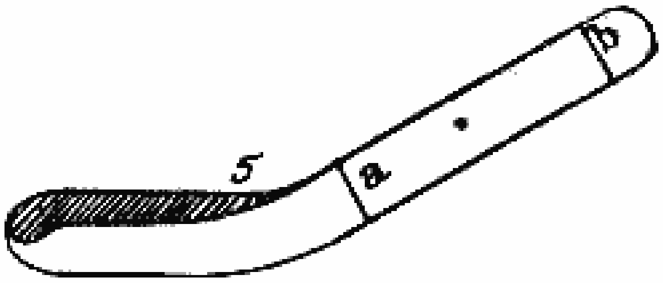

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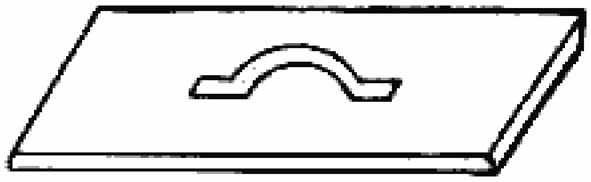

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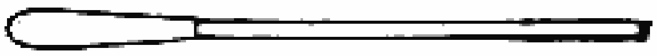

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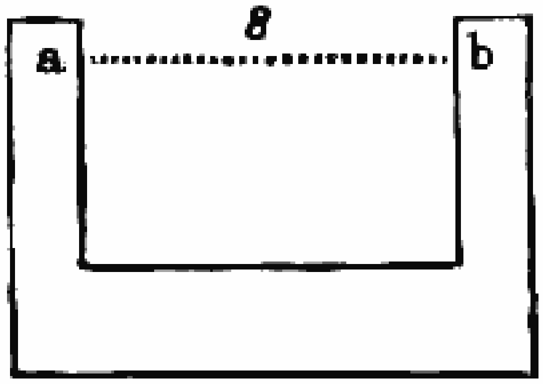

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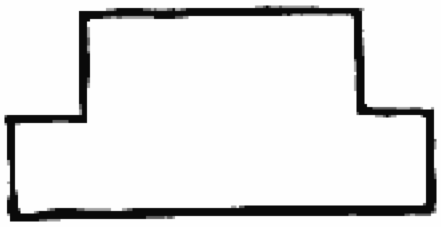

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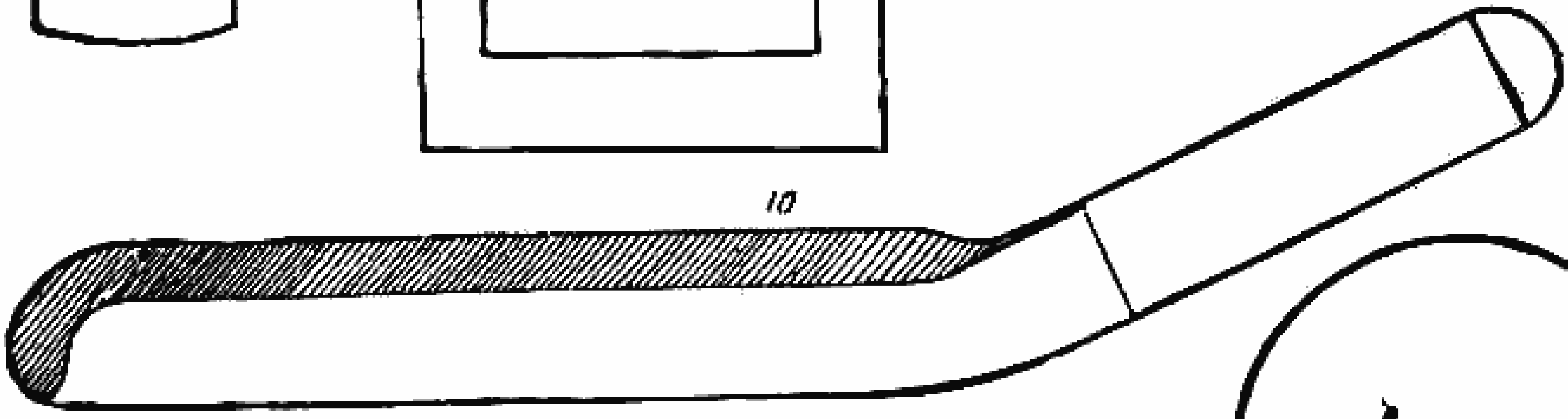

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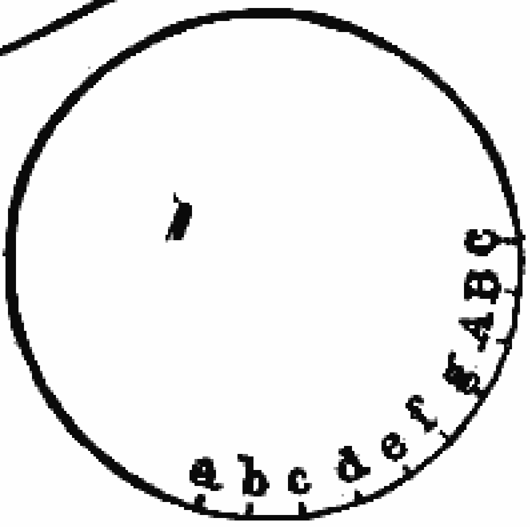
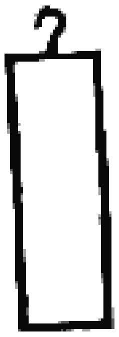


11

A
B
C
g
f
e
d
c
b
a



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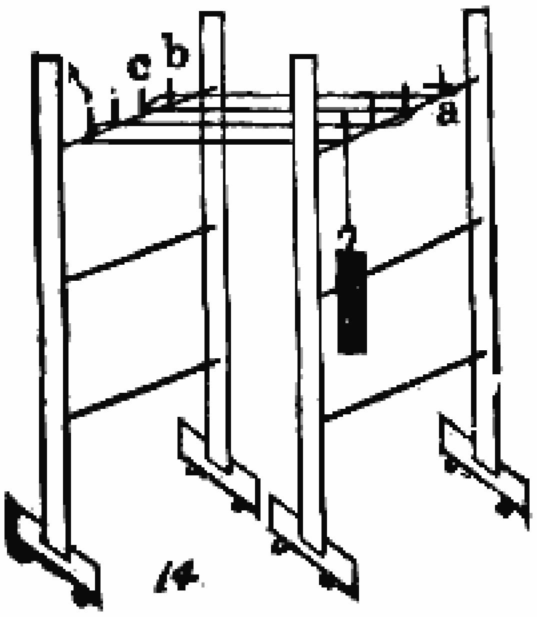

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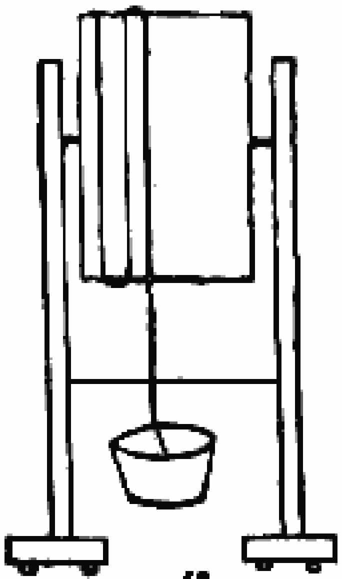

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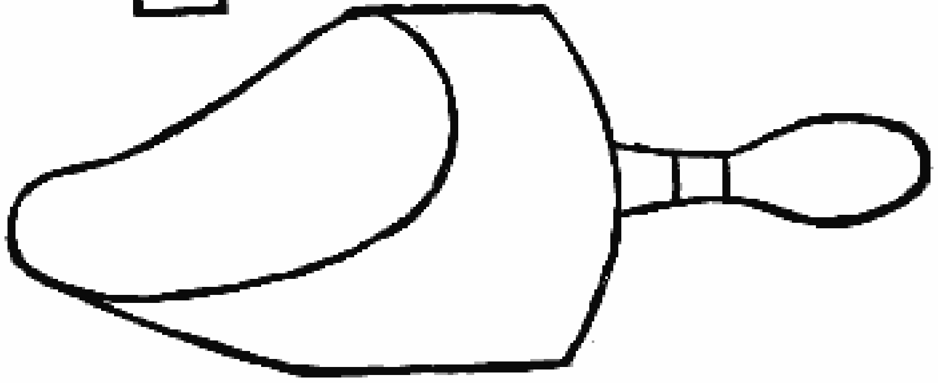

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powder may be crushed in a leather bag by laying the bag on a hard surface and beating it with a hammer. The leather should be of the same kind as shoes are made of.

To Charge Roman Candle Cases.—Pour some F grain powder into a wooden bowl or platter, represented by Fig. 11. Round the edge lay the little blowing powder scoops side by side, beginning with the smallest at *a*, the next at *b*, and so on to *g*. Put some Roman candle fuse into a large tin scoop, made to stand on a flat bottom, like Fig. 12, the same in shape as used by tea dealers; and, on the right hand of it lay the charging fuse scoop, Fig. 10. If the Roman candle is to contain different colored stars, set seven in a row in the order desired. When the cases are intended to be fired in threes or fours, the stars in one may be all blue, in another crimson, in another green, in another white. Fit the foot, Fig. 9, in the bottom of the case, put in a scoopful of clay, insert the rammer, Fig. 4, and jolt it till the clay is well composed. The clay should fill half an inch. This being done, invert it, and shake out any little dust that may remain. Put in the little scoopful, *a*, of F grain powder, then lay the scoop at A. Now put in a star. As previously stated, it ought to fall of its own accord; but make sure that it has reached the blowing powder by putting in the rammer. Having ascertained this, put in a scoop of fuse, Fig. 10; lay the scoop on the right of Fig. 12; insert the rammer and jolt it; put in another scoop of fuse, Fig. 10; lay the scoop on the right of Fig. 12; insert the rammer and jolt it as before. Then proceed with the scoop, *b*, of grain powder and lay it at B, and so on, till the case is filled. The fuse on the top star is best driven in with a short solid rammer and mallet, as it is difficult to jolt the long rammer in so small a space. The last eighth of an inch, near the mouth of the case, should be fine meal powder, as it binds better than the Roman candle fuse, and also blows off the leader pipe.

The blowing powder scoops, having been laid at A, B, etc., all that is required is to turn the bowl or platter a little round to the left and they will come in rotation ready for the next case. Also, by putting the scoop, Fig. 10, alternately to the left and right of the scoop, Fig. 12, it will always be known whether the proper quantity of fuse has been put in.

Colored stars, from their fierceness, have a tendency to burn in the cases. This defect may be remedied by putting upon each star a small coopful of starting fire, No. 1, before putting in the interval fuse as much as will fill round the sides of the star. This composition is somewhat fiercer than would suit for the regular fuse; so catches the blowing powder sooner.

A Roman candle is well charged when the stars isochronize, or come out at equal intervals of time; they should also, theoretically, ascend to equal heights; but with colored stars this cannot be perfectly insured, as some shrink more than others in drying, and of course fit more loosely; some are heavier, some fiercer than others.

The interval fuse must always be driven in at twice, never at once. Each star, with its blowing powder and fuse, occupies about an inch and a half; perhaps a trifle more.

Instead of driving in clay at the bottom, plaster of Paris may be used, and then the foot, Fig. 9, will not be required. Have some plaster of Paris in a wide-mouthed bottle; a glass of cold water with a salt spoon in it; and a number of pieces of paper about four inches square. Put a small quantity of the plaster on one of the pieces of paper; indent the middle with the finger; put to it a little water and work it up with a dessert knife. Just as it gets to the consistency of mortar and is about to set, mould it with the fingers to the shape of a cork; push it in to the end of the case; rest the case on a flat surface; insert the rammer and give it two or three slight jolts; turn it round a few times and withdraw it. If the plaster sticks to the end of the rammer, it shows either that you have used the plaster too wet or have not turned the rammer round a sufficient number of times.

No more plaster must be mixed at a time than will suffice for one case. When plaster has once set it cannot be mixed up a second time; therefore take a fresh piece of paper and let the knife be cleaned every time. It is advisable to have two dessert knives, then one can be used to scrape the other. As much plaster should be used as will fill the case up about half an inch. They must be set by to dry; their not requiring the use of the foot will be found a great convenience.

Roman candles are usually made from three-eighths to six-eighths, but five-eighths is a very satisfactory size. If a Roman candle is intended to be fired singly, twist a piece of touch paper round the mouth. If the cases are intended to be fired in threes, fours, etc., to form a bouquet, or to be placed round a mine, jack-in-the-box, or devil-among-the-tailors, omit the touchpaper and envelop the case in double crown, made to project an inch beyond the mouth, to receive the leader or quick-match.

A steel pen inserted, nib backward, in the end of a small paper tube, rolled round the end of a pen holder, makes a neat little scoop. It may be fastened in with a little plaster of Paris. A scoop may also be made with a quill.

Composition for Roman Candles.—1. Niter, 18 parts; sulphur, 6 parts; fine charcoal, 7 parts; meal powder, 4 parts.

2. Niter, 16 parts; meal powder, 8 parts; fine charcoal, 8 parts; sulphur, 6 parts.

3. Niter, 16 parts; meal powder, 11 parts; sulphur, 6 parts; antimony, 4 parts. The next thing is to fill the case. Before filling it introduce a little clay to the bottom of the case, thus forming a better and firmer bottom. This being done properly, put in a little coarse pow-

der, and over this a small piece of paper to prevent the composition mixing with the powder; then ram down as much composition as will fill the case one-sixth of its height; over this put a small piece of paper covering about two thirds of the diameter, then a little corn powder, and upon that a ball, observing that the ball is rather smaller than the diameter of the case. Over this first ball more of the composition must be put and rammed lightly down to prevent breaking the ball, till the case is one third full; then a piece of paper, a little powder, and then another ball as before, till the case is filled with balls and composition, taking care to place composition above the highest ball. When the case is thus filled, cap it with touch paper by pasting it round the orifice, and a little priming of powder being added, the work is complete.—*Pyrotechnist's Treasury.*

Saxon.

Number	1	2	3
Sulphur	1	3	5
Niter	1	4	9
Meal powder	2	5	15

Shell Fuse.

Number	1
Meal powder	4
Niter	2
Sulphur	1

Signal Fireworks.—The following proportions are given in an English patent by E. H. Lamarre, of Paris, for colored lights for signals:

White Light.—One hundred parts potassium chlorate, 10 parts antimony sulphide, 15 parts boiled linseed oil.

Red Light.—Fifty parts potassium chlorate, 50 parts strontium nitrate, 5 parts wood charcoal, with as much linseed oil as is required to knead the mass together.

Green Light.—Fifty parts potassium chlorate, 50 parts barium nitrate; 5 parts wood charcoal and linseed oil, as above. The use of linseed oil is claimed as a specialty in substitution for oil of turpentine or resin.—*Science Record*, 1874.

To Make Slow Match.—Dissolve 1 drm. nitrate of lead in ½ oz. boiling water. Cut a sheet of blotting paper in six equal parts, and wet them on both sides, with a sash tool, with the solution. When dry, paste a piece all over, and upon it smoothly press another piece; upon this, pasted, put a third piece; and so on, till all the six form a stiff board. Lay them under a heavy weight; and, when dry, with a sharp knife and straight edge, cut the whole into strips a quarter of an inch broad. Four inches will burn about a quarter of an hour. Narrow tape, boiled in the solution, makes excellent slow match.

Squibs, Compositions for.—1. Meal powder, 20 parts; niter, 8 parts; sulphur, 4 parts; E. charcoal, 4 parts.

2. Meal powder, 16 parts; E. charcoal, 2 parts.

3. Meal powder, 24 parts; niter, 4 parts; E. charcoal, 4 parts; sulphur, 1 part.

4. Meal powder, 16 parts; niter, 6 parts; sulphur, 4 parts; E. charcoal, 3 parts. Weigh out all the ingredients, mix them thoroughly, and pass the composition through a sieve at least three times. The composition cannot be overmixed.

Slow Fires, to be Heaped upon a Tile in Shape of a Cone, and Lit at Top.

Colors.	Scarlet.			Green.			Purple.		Yellow.		Crimson.	
Nitrate of strontium	16	24	108	—	—	—	108	72	20	—	40	36
Nitrate of barytes	—	—	—	16	16	16	—	—	—	10	—	—
Oxalate of soda	—	—	—	—	—	—	—	—	3	5	—	—
Sulphure of copper	—	3	30	—	—	—	24	3	—	—	—	—
Chlorate of barytes	—	—	—	—	—	12	—	—	—	—	—	—
Chlorate of potash	1	3	12	1	1	—	9	4	2	2	5	4
Charcoal, fine	1	—	—	1	—	—	—	—	—	—	2	—
Calomel	—	6	24	—	5	9	24	18	—	—	—	—
Sulphur, washed	4	8	39	4	2	7	39	24	4	1	13	12
Shellac	—	1	2	—	2	1	2	3	2	6	—	1
Vegetable black	—	—	1	—	—	—	1	2	—	—	—	1
Sulphide of antimony	—	—	—	—	—	—	—	—	—	—	4	4

In order to get the powder into a conical heap, press it into a wineglass, or lay a tile upon the top, and invert.

Squib and Serpent.

Number	1	2	3
Sulphur	1	—	—
Charcoal	1	1	—
Niter	2	—	—
Meal powder	8	8	4
Steel filings	—	—	1

Stars, Crimson. — 1. Chlorate of potash, 24 parts; nitrate of strontia, 32 parts; calomel, 12 parts; sulphur, 6 parts; shellac in fine powder, 6 parts; sulphide of copper, 2 parts; fine charcoal, 2 parts.

2. Chlorate of potash, 12 parts; nitrate of strontia, 20 parts; sulphur, 11 parts; charcoal, 2 parts; antimony, 2 parts; mastic, 1 part.

3. Nitrate of strontia, 72 parts; sulphur, 20 parts; gunpowder, 6 parts; coal dust, 2 parts.

Rose Colored Stars.—Chlorate of potash, 20 parts; carbonate of strontia, 8 parts; calomel, 10 parts; shellac, 2 parts; sulphur, 3 parts; fine charcoal, 1 part. The advantage of this composition is that it is not at all liable to suffer from damp in winter. The carbonate of strontia is a salt not absorbent of moisture like the nitrate, and is, moreover, always to be had in a state of fine powder.

Green Stars.—1. Chlorate of potash, 20 parts; nitrate of baryta, 40 parts; calomel, 10 parts; sulphur, 8 parts; shellac, 3 parts; fine charcoal, 1 part; fused sulphide of copper, 1 part.

2. Nitrate of baryta, 40 parts; realgar, 2 parts; sulphur, 8 parts; lampblack, 1 part.

3. Chlorate of potash, 28 parts; nitrate of baryta, 12 parts; sulphur, 15 parts; mastic, 1 part.

Pale Rose Colored Stars.—Nitrate of strontia, 8 parts; chlorate of potash, 4 parts; sulphur, 3 parts; sulphuret of antimony, 2 parts. Take especial care that the nitrate of strontia used in this formula is very dry.

Pale Green Stars.—Nitrate of baryta, 16 parts; chlorate of potash, 8 parts; sulphur, 6 parts; antimony, 3 parts.

Yellow Stars.—1. Chlorate of potash, 20 parts; bicarbonate of soda, 10 parts; sulphur, 5 parts; mastic, 1 part.

2. Chlorate of potash, 30 parts; dried soda, 12 parts; sulphur, 8 parts.

Golden Yellow Stars.—Chlorate of potash, 20 parts; nitrate of baryta, 30 parts; oxalate of soda, 15 parts; sulphur, 8 parts; shellac, 4 parts. If it is thought advisable to give the stars made from this formula a tailed appearance, add one part of fine charcoal. The composition is to be moistened with the shellac solution. The stars form a beautiful contrast with those of an intense blue.

Blue Stars.—1. Chlorate of potash, 8 parts; sulphide of copper, 6 parts; Chertier's copper, 5 parts; sulphur, 4 parts.

2. Chlorate of potash, 12 parts; Chertier's copper, 6 parts; sulphur, 4 parts; calomel, 1 part.

3. Chlorate of potash, 16 parts; Chertier's copper, 12 parts; calomel, 8 parts; stearine, 2 parts; sulphur, 2 parts; shellac, 1 part. This gives a most intense blue.

4. Chlorate of potash, 20 parts; carbonate of copper, 14 parts; sulphur, 12 parts; mastic, 1 part.

5. Niter, 12 parts; sulphide of antimony, 2 parts; sulphur, 4 parts; lampblack, 2 parts. All these compositions should be moistened with gum water, and in No. 3 the stearine employed must be in fine powder.

Violet Stars.—Chlorate of potash, 9 parts; nitrate of strontia, 4 parts; sulphur, 6 parts; carbonate of copper, 1 part; calomel, 1 part; mastic, 1 part.

White Stars.—Saltpeter, 9 parts; sulphur, 3 parts; antimony, 2 parts.

No. 1. *Mauve and Lilac Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10
Chlorate of potash	28	17	60	40	25	24	24	25	12	6
Calomel	12	—	—	—	10	12	12	—	—	2
Shellac	4	—	—	—	5	5	5	—	—	1

No. 3. *Purple and Violet Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Chlorate of potash	42	28	48	16	6	16	3	6	26	30	96	24	20	32	37
Nitrate of strontium	42	14	48	—	4	—	—	1	—	—	24	—	—	—	—
Sulphur, washed	13	—	28	2	1	6	1	3	—	3	—	2	6	12	9
Calomel	12	14	28	7	2	6	2	2	20	8	48	8	8	12	13
Sulphide of copper	4	1	40	8	1	—	3	—	8	12	1	—	—	—	—
Shellac	4	5	1	—	1	—	—	—	—	4	—	1	1	2	8
Vegetable black	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Black oxide of copper	—	—	—	—	—	4	4	1	—	—	—	—	—	1	1
Carbonate of strontium	—	—	—	—	—	—	—	—	4	12	—	—	—	—	—
Loaf sugar	—	—	—	—	—	—	—	—	14	—	42	—	—	—	—
Oxychloride of copper	—	—	—	—	—	—	—	—	—	—	—	4	5	8	9
Stearine	—	—	—	—	—	—	—	—	—	—	—	2	2	—	1

Nitrate of strontium..	4	4	25	14	—	4	—	16	16	1
Sulphide of copper....	2	7	20	—	5	2	2	—	—	1
Stearine..............	1	—	—	—	1	—	1	—	—	—
Sulphur, washed.......	—	7	35	16	—	—	—	12	2	—
Chloride of lead.......	—	1	—	2	—	—	—	—	—	—
Nitrate of lead........	—	—	—	—	10	—	12	1	—	—
Oxychloride of copper.	—	—	8	12	—	—	—	6	—	—
Salammoniac..........	—	—	1	—	—	—	—	—	—	—
Vegetable black......	—	—	—	1	—	—	—	1	1	—
Niter................	—	—	—	2	—	—	—	2	1	—
Carb'nate of strontium	—	—	—	—	5	—	4	—	—	—
Orpiment or realgar...	—	—	—	—	—	—	1	—	1	—

The following refers to table No. 6, page 18: If powdered nitrate of barytes and shellac, crushed by being hammered in a bag, are mixed together and melted in a pipkin over the fire, the mixture, when cold, may be reduced to a powder in an iron mortar with patience. Take No. 6. Weigh out 21 parts nitrate of barytes, and 2 parts coarsely powdered lac; melt them together; when cold, powder them, and add the other substances in proper proportion. Shellac may be melted with nitrate of strontian, in the same way.

No. 2. *Sugar Blues for Stars and Lances.*

Number...........	1	2	3	4	5	6	7	8	9	10
Chlorate of potash....	8	36	40	40	36	9	44	40	6	2
Calomel..............	4	18	24	24	12	3	12	—	5	1
Loaf sugar..........	3	12	9	12	4	1	12	9	4	—
Sulphuret of copper.	5	22	22	12	4	3	12	22	—	—
Stearine............	—	1	2	1	3	1	1	2	—	—
Oxychloride of copper	—	—	—	3	4	2	5	—	—	—
Salammoniac........	—	—	—	—	—	—	—	6	—	—
Copper filings........	—	—	—	—	—	—	—	—	1	—
Black oxide of copper	—	—	—	—	—	—	—	—	—	—

No substance combines better with salts of copper than sugar. Sugar, put into the bowl of a tobacco pipe and placed in the fire, burns fiercely, and is converted into caramel. This poured on to a plate, slightly smeared with butter to prevent it sticking, hardens on cooling; and is used for coloring brandy, vinegar, gravy, porter, coffee, etc. Stearine must be scraped very fine from a Stearine candle. Sugar blues are to be damped with pure water only, as the sugar itself, when wetted, is sufficiently cohesive. Use an exceedingly small quantity of water, and rub it up thoroughly in the mortar; the longer it is rubbed, the better it combines.

The following refers to table No. 10, page 19: It is impossible to powder shellac sufficiently fine by hand; and, twenty years ago, powdered shellac could not be procured. About that time the drug grinders, finding a demand for it, submitted it to the action of the stamping mills (mechanical pestle and mortar), and now it can be obtained at most shops.

Chertier mixed flake shellac with salt; melted the two together; powdered the mixture; and washed out the salt. Such process is needless now. It is useless, unless as fine as wheaten flour.

No. 4. *Steel Stars for Rockets and Shells.*

Number.	1	2	3	4	5
Nitrate of lead..	8	24	28	—	—
Chlorate of potash	3	5	6	5	4
Charcoal.........	2	6	6	1	—
Steel filings......	2	6	6	3	4
Niter............	—	4	3	—	—
Shellac, fine......	—	—	1	—	—
Sulphur, washed	—	—	—	1	1

Rub up the mixture thoroughly in a mortar with just enough boiled oil to make it cohere, and pump it into Roman candle stars; the oil will preserve the steel from rusting. For Roman candles or Italian streamers they will be ready at any time; for rockets and shells they may be matched and enveloped, like figure 32, a day or two previously. They form beautiful stars. Or they may be charged in cases, and primed with chlorate meal powder. Or they may be damped with lac solution.

No. 5. *Pearl Streamer.*

Number.........	1	2	3	4	5
Niter............	12	26	2	—	—
Charcoal	5	11	1	—	—
Zinc filings......	14	28	4	10	15
Meal powder. ...	—	—	1	8	12
Vegetable black.	—	—	—	1	1

Instead of filings, zinc may be obtained in a fine powder, by pouring it, melted, into a hot iron mortar, and hammering it with the pestle directly it begins to solidify. Sift it through a fine sieve. Protect the hands with cloth gloves while using the pestle. Damp the composition with gum water for Roman candle stars. Broken bits of the stars may be put into colored gerbes.

No. 6. *Green or Emerald Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Chlorate of potash	16	8	132	32	144	8	3	1	—	16	6	12	16	3	48	22	24	108	24	16	2	13
Nitrate of barytes	16	8	108	54	160	21	2	—	—	8	7	5	8	3	42	22	32	108	32	48	10	32
Chlorate of barytes	—	—	—	—	—	3	2	2	4	8	3	4	4	—	—	—	—	—	—	—	—	—
Sulphur, washed	5	4	6	6	4	7	1	1	1	5	—	—	1	—	—	—	10	18	8	12	2	8
Charcoal, fine	1	1	—	—	—	1	—	—	—	1	—	1	—	—	—	—	—	—	—	1	1	2
Sulphide of antimony	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
Calomel	—	—	48	27	100	—	—	—	—	—	5	2	2	2	—	10	—	48	—	8	—	—
Shellac	—	—	24	12	12	2	—	—	—	—	—	3	4	—	7	1	—	24	—	5	—	—
Vegetable black	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—
Loaf sugar	—	—	—	—	—	—	—	—	—	—	5	—	—	2	7	14	—	—	—	—	—	—
Sal ammoniac	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—
Orpiment, or Realgar	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3	—	—	—
Sulphide of copper	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—

No. 7. *Deep and Pale Yellow Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Chlorate of potash	8	4	12	16	12	16	4	4	16	8	8	16	16	4	8	6	20	5	6
Oxalate of soda	3	2	8	4	4	4	3	1	4	4	4	5	—	1	—	4	15	—	3
Bicarbonate of soda	—	—	—	—	—	—	—	—	—	—	—	—	3	—	3	—	—	1	—
Nitrate of strontium	—	—	—	—	—	—	20	—	—	—	16	—	4	—	—	—	—	—	—
Carbonate of strontium	—	—	—	3	2	8	—	—	—	—	—	—	—	—	—	—	—	—	—
Nitrate of barytes	—	—	—	—	—	—	—	—	4	10	—	—	3	—	—	7	30	—	—
Sulphur, washed	—	—	—	4	4	4	—	1	2	—	61	5	—	—	—	3	8	1	2
Shellac	2	1	3	—	1	1	5	—	2	3	1	—	4	1	—	1	4	—	1
Stearine	—	—	—	—	—	1	—	—	1	—	—	—	—	—	—	—	—	—	—
Charcoal, fine	—	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	1	—	—
Orpiment, or realgar	—	—	—	1	1	1	—	—	—	—	—	—	—	—	1	—	—	1	—
Loaf sugar	—	—	—	—	—	—	—	—	—	—	—	—	—	1	3	—	—	—	—

No. 8. *White or Bright Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Meal powder	3	3	2	1	1	1	1	1	3	—	—	—	—	—	—
Sulphur	4	6	4	2	8	2	2	1	11	5	7	—	8	2	1
Niter	8	14	14	5	10	6	9	4	48	24	34	18	—	—	—
Sulphide of antimony	1	—	1	—	3	—	2	1	10	5	6	3	1	1	2
Sulphide of arsenic, realgar	—	—	—	1	—	1	—	—	—	3	5	—	—	—	—
Minium, or red lead	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—
Nitrate of lead	—	—	—	—	—	—	—	—	—	—	—	3	16	3	12
Chlorate of potash	—	—	—	—	—	—	—	—	—	—	—	28	16	4	3
Shellac	—	—	—	—	—	—	—	—	—	—	—	5	—	—	1

No. 9. *Blue Stars and Lances without Sugar.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Chlorate of potash	5	40	18	40	6	8	48	40	24	16	30	24	8	22	40	6	16	24	2	5	40	40	36
Calomel	4	20	8	28	2	2	12	12	6	8	10	8	1	8	20	3	1	8	—	—	—	—	12
Sulphide of copper	4	20	10	28	—	2	—	—	—	—	—	—	3	6	25	5	—	—	—	1	20	22	—
Shellac	1	5	—	—	—	—	2	2	1	—	—	1	—	—	5	—	—	1	—	—	6	—	6
Oxychloride of copper	—	2	—	—	—	—	8	—	6	5	10	4	1	2	—	—	2	—	1	1	—	—	9
Dextrine	—	—	5	10	—	—	—	9	—	—	..	—	—	..	2	2	—	—	—	—	—	—	—
Sulphur	—	—	—	..	3	4	4	1	1	2	3	2	3	5	—	—	4	2	1	2	5	5	9
Stearine	—	—	—	3	—	—	1	—	2	2	3	1	—	—	—	—	—	—	—	—	—	3	1
Black oxide of copper	—	—	—	—	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Copper filings	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	—	—	—	—	—
Sal ammoniac	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	6	6	—

No. 10. *Crimson and Scarlet Stars and Lances.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Chlorate of potash	16	8	16	16	24	16	24	16	8	16	25	4	32	6	16	28	32	26	96	8	24	8	2	13
Nitrate of strontium	16	16	32	32	—	16	20	24	5	6	30	7	48	5	—	—	42	10	72	12	18	12	8	32
Sulphur, washed	5	6	9	12	6	5	10	—	1	—	10	1	6	—	—	—	13	5	24	2	—	2	2	8
Charcoal, fine	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	2
Shellac	—	1	4	2	2	—	—	7	1	4	3	1	12	1	—	—	4	3	21	4	5	3	—	—
Calomel	—	—	7	—	6	1	—	14	2	2	9	2	12	5	—	12	12	10	42	—	—	4	—	—
Sulphide of copper	—	—	3	1	—	—	—	1	1	1	3	1	—	1	—	—	4	1	4	1	5	—	—	—
Realgar, or orpiment	—	—	—	—	—	1	5	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Vegetable black	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1	—	—	—	—	1	—	—
Loaf sugar	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	12	—	—	—	—	—	—	—	—
Carbonate of strontian	—	—	—	—	10	—	—	—	—	—	—	—	—	—	11	5	—	—	—	—	—	—	—	—

No. 11. *Tailed, Streamer, or Comet Stars, for Rockets, Shells and Roman Candles.*

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Vegetable black	1	3	3	6	—	—	—	—	3	1	—	—	—	—
Charcoal	2	8	2	3	1	3	6	12	2	4	1	1	3	—
Sulphur	5	24	2	—	2	4	1	2	2	12	3	3	8	—
Nitter	5	24	9	—	—	—	10	20	9	12	4	4	4	—
Meal powder	8	30	6	16	—	20	5	7	6	8	3	3	12	2
Oxalate of soda	—	—	—	—	4	12	—	—	—	—	—	—	—	—
Sulphide of antimony	—	—	—	—	—	—	—	—	4	—	—	—	—	—
Chlorate of potash	—		—	—	8	16	—	—	—	—	—	—	—	—
Asphaltum, Egyptian	—	—	—	—	—	—	—	—	—	—	1	—	—	—
Burgundy pitch	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Coke grains, fine	—	—	—	—	—	—	—	—	—	—	—	—	4	1

Tourbillion.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Sulphur	1	3	3	7	3	4	4	4	2	4	1	7	4	1
Niter	4	5	16	10	8	32	17	17	4	8	8	20	14	4
Charcoal	2	3	8	4	3	6	4	5	—	—	—	—	3	2
Meal powder	1	4	8	24	16	32	—	—	4	9	10	20	13	1
Steel filings	—	—	—	8	6	5	—	—	—	—	—	—	2	1
Cast iron borings	—	—	—	—	—	8	6	8	8	4	7	14	5	--

Oiled Tailed Stars for Rockets and Shells.

Number	1	2	3
Charcoal	9	6	2
Sulphur	9	5	2
Niter	32	18	9
Meal powder	24	12	5
Sulphide of antimony	16	9	4

To 1 oz. add 24 drops of boiled linseed oil; rub them thoroughly together in a mortar; then spread out the mixture for a few days to dry. When dry, mix with starch, dextrine solution, or gum water, and chop into ⅜ or ½ in. cubical blocks. They will keep for years, and improve by age. In order that a star may tail, it must rapidly burn through and leave a cinder, or scoria; from this, as it falls, minute portions become detached, and trail behind.

Magnesium Colors for Stars and Asteroids.

Colors.	Crimson.	Scarlet.	Green.	Blue.	Yellow.	White.
Nitrate of strontium	8	6	—	—	—	—
Chloride of barytes	—	—	12	—	—	—
Oxychloride of Copper	—	—	—	2	—	—
Oxalate of soda	—	—	—	—	2	—
Sulphide of antimony	—	—	—	—	—	1
Chlorate of potash	2	4	—	5	4	—
Niter	—	—	—	—	—	12
Sulphur	2	2	1	2	—	4
Charcoal	1	—	—	—	—	—
Shellac	—	2	3	1	1	—
Calomel	—	4	—	2	—	—
Magnesium filings	2	3	2	2	1	2

A few magnesium filings may be added to any color.

Star Lights, Composition for.—Fine dry niter, 20 parts; sulphur, 6 parts; lampblack, 3½ parts.

Starting Fire.

Number	1	2	3
Charcoal	1	3	2
Meal powder	8	16	12
Sulphur	—	4	2
Niter	—	6	3

Streamers.—Streamers or quick matches, used for communicating fire quickly from one tube to another in display pieces, are composed of the following composition packed in slender continuous paper tubes:

Niter	2	oz.
Sulphur	1	oz.
Mealed powder	16	oz.
Charcoal	4	oz.

To Make Touch Paper.—Dissolve ½ oz. of niter in ½ pt. of hot water. Procure some 12 lb. double crown blue, cut each sheet into four equal parts, fifteen by ten. Lay them smooth upon each other, and, with a sash tool dipped into the niter solution, wash them over on one side, and hang them up to dry.

Wasp Light.

Number	1
Nitre	14
Sulphur	5
Meal powder	3
Realgar	1

Wheel and Fixed Cases.

Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Meal powder	8	24	8	36	4	18	8	12	42	4	16	10	13	16	20	40	38
Sulphur	1	1	—	1	—	—	1	1	3	—	—	—	1	—	1	4	1
Charcoal	1	4	1	4	1	—	—	—	—	—	—	—	—	—	—	3	2
Niter	2	3	—	—	2	2	1	3	8	—	2	—	1	—	—	24	4
Steel filings	—	—	—	—	—	5	3	3	5	1	5	—	—	—	—	6	—
Vegetable black	—	—	—	—	—	—	—	—	—	—	—	1	2	—	—	1	—
Realgar	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1	—
Litharge	—	—	—	—	—	—	—	—	—	—	—	—	—	3	3	2	—

Case Colors for Wheels, Compositions for—1. White.—Niter, 10 oz.; sulphur, 3 oz.; regulus antimony, 2 oz.; realgar, 1 oz.; red lead, ½ oz.; shellac, ½ oz.

2. Golden Yellow.—Potassium chlorate, 8 oz.; barium nitrate, 2 oz.; shellac, 2 oz.; sodium oxalate, 1½ oz.; stearine, ½ oz.

3. Orange.—Potassium chlorate, 8 oz.; strontium chlorate, 1 oz.; barium nitrate, 2 oz.; shellac, 2 oz.; sodium oxalate, 1½ oz

4. Mauve.—Potassium chlorate, 12 oz.; mercurous chloride, 4 oz.; strontium nitrate, 2 oz.; copper subsulphate, 2 oz.; shellac, 2 oz.; stearine, ½ oz.

5. Rich Crimson.—Potassium chlorate, 9 oz.; strontium nitrate, 5 oz.; shellac, 2 oz.; mercurous chloride, 1½ oz.; copper sulphide (fused), 1 oz.; lampblack, ¼ oz.

6. Red.—Potassium chlorate, 8 oz.; strontium nitrate, 5 oz.; shellac, 2 oz.; mercurous chloride,

1 oz.

7. **Brilliant Green.**—Potassium chlorate, 10 oz.; barium nitrate, 5 oz.; shellac, 2 oz.; mercurous chloride, 2 oz.; pure sulphur, 1 oz.; copper sulphide, ¾ oz.; fine charcoal, ½ oz.

8. **Rich Emerald Green.**—Potassium chlorate, 12 oz.; barium nitrate, 9 oz.; barium chlorate, 5 oz.; shellac, 4 oz.; mercurous chloride, 2 oz.; copper powder, 1 oz.; pure sulphur, 1 oz.

9. **Bright Blue.**—Potassium chlorate, 7 oz.; mercurous chloride, 4 oz.; Chertier's copper, 4 oz.; dextrine, 1½ oz.; stearine, ½ oz.

10. **Bright Blue.**—Potassium chlorate, 8 oz.; Chertier's copper, 7 oz.; mercurous chloride, 3 oz.; shellac, 1 oz.; stearine, 1 oz.

11. **Rich Blue.**—Potassium chlorate, 8 oz.; copper subchloride, 2 oz.; shellac, ½ oz.; mercurous chloride, 3 oz.; stearine, 1 oz.

All the ingredients must be perfectly dry and fine enough to pass through a forty mesh sieve. They should be thoroughly well mixed and the compositions should be kept in stoppered bottles ready for use.

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Pyrotechny. This is the art of making fireworks. The three principal materials employed in this art are charcoal, saltpetre, and sulphur, combined with filings of iron, steel, copper or zinc, or with resin, camphor, lycopodium and other substances, to impart color, or to modify the effect and duration of the combustion. Gunpowder is used, either in grain, half crushed, or meal (finely ground), as circumstances may require. Iron filings give red and bright spots. Copper filings give a greenish tint to flame; those of zinc, a fine blue color; sulphuret of antimony gives a less greenish blue than the zinc, but with much smoke; amber, resin and common salt afford a yellow fire. Lycopodium burns with a rose color and a magnificent flame, &c.

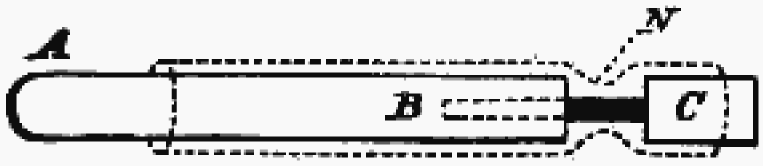
2049. The Leading Fireworks. The leading simple fireworks are rockets, Roman candles, flowerpots or gerbs, mines, and their adaptations or varieties; quick fires of different kinds and colors in cases, such as golden rain, spur fire, &c.; slow fires in cases and pots, as blue lights, Bengal lights, &c. These form the fundamental principles of all pyrotechnic display. The endless variety of their combinations in the shape of vertical and horizontal wheels and "set pieces," requires considerable fertility of invention and mechanical ingenuity, combined with a thorough practical knowledge of the nature of firework compositions, and the appropriate means of displaying them to the best advantage. The weights used in the following receipts are avoirdupois.

2050. To Make Plain Rockets. The cases are made of stout cartridge paper, rolled on a rod whose thickness is equal to the desired diameter of the bore. The rod is slightly tapering, to allow of its easier withdrawal after the case is rolled and pasted. The narrower end of the case is choked; that is, a neck is made in it, similar to the neck of a phial. (*See No.* 2053.) The composition (*see No.* 2054) is next rammed tightly into the case (*see No.* 2052), which is supported by a closely fitting mould during this operation, finishing with a small charge of gunpowder to explode when the rocket goes out. The top of the case is then stopped with clay and a conical cap fastened on, to decrease the resistance of the air in its upward flight; and the bottom or choked end of the case is furnished with priming and touch-paper. The whole is secured to the end of a willow stick, to direct its course through the air.

2051. To Make Display Rockets. Rockets whose discharge ends in display, are furnished with an extra case, called the pot, about ¼ the length of the rocket; its inside diameter is the same as the outside diameter of the rocket case, over which it is glued firmly, and takes the place of the conical cap. The *garniture*, consisting of stars, serpents, &c., as the case may be (*see No.* 2055), is inserted in the pot and connected with the charge in the rocket case by a quick match. (*See No.* 2060.) The whole is finished with the clay and cap, the same as the head of a simple rocket.

2052. To Charge Rocket Cases. In charging rocket cases, in order to increase the rapidity of its discharge a wire is sometimes inserted through the centre of the charge, the rammer being constructed with a small bore through its length, to receive this wire when ramming the charge. This wire is withdrawn when the charge is complete, and the space it has left is filled with a quick match (*see No.* 2060), which thus sets fire to the entire charge at once. This central space is called the soul of the rocket, and the adoption of this arrangement is necessary for large rockets, especially those having heavy pots.

2053. To Choke Firework Cases. A short cylindrical piece of wood, of the same diameter as the thin end of the rod used for rolling a case, is furnished with a wire, the thickness of which must be the same as the desired bore of the choke. The end of the rod has a hole bored in it to receive this wire loosely. A is the rod on which the case is to be rolled; C the cap of the same diameter as the end of the rod, having the wire inserted firmly in its axis. The rod is bored, as the dotted lines at B denote, to receive the wire. The outside dotted lines indicate a case on the rod, choked at N. This is effected by stretching a piece of strong cord, a single turn of which is passed round the case at N, compressing it firmly and leaving a bore of the same size as the wire between the rod and the cap. In rolling a case to be choked, the paper should be used in pieces, each piece wide enough to make about 3 thicknesses when rolled over the rod, and the choking done after each piece is rolled. When finished, the rod is withdrawn from the mouth of the case, and the cap and wire from the other end.



2054. Composition for Rockets. For 2 ounce rockets:—Mix 54½ parts nitre (saltpetre), 18 parts sulphur, and 27½ of charcoal, all in fine powder. Sift through lawn. For 4 ounce rockets:—64 parts nitre, 16 parts sulphur, and 20 parts charcoal. For 8 ounce to 1 pound rockets:—62¾ parts nitre, 15¼ parts sulphur, and 21½ parts charcoal. For rockets ¾ inch in diameter:—16 parts nitre, 4 parts sulphur, and 7 parts charcoal. For rockets 1½ inches in diameter use 1 part more nitre, and for still larger rockets, another additional part nitre. By using 1 part less charcoal, and adding respectively 3, 4, and 5 parts fine steel filings, the above are converted into *brilliant fires;* or, by using coarse iron filings, and still less charcoal, they become *Chinese fire.*

2055. Chinese Fire for Sky Rockets. If ¾ inch or under, nitre, 16 parts; charcoal, 4 parts; sulphur, 8 parts; cast-iron borings, 4 parts. Mix. Or: If over 1 inch and under 2 inches bore, nitre 16 parts; charcoal, 4 parts; sulphur, 4 parts; iron borings, 5 parts. Mix.

2056. Golden Rain. Mealed powder, 4 ounces; saltpetre, 1 pound; sulphur, 4 ounces; brass filings, 1 ounce; sawdust, 2½ ounces; glass powder, 6 drachms.

2057. Silver Rain. Mealed powder, 2 ounces; saltpetre, 4 ounces; sulphur, 1 ounce; steel dust, ¼ ounce.

2058. Trailed Stars for Rockets and Roman Candles. Saltpetre, 4 ounces; sulphur, 6 ounces; sulphate of antimony, 2 ounces; resin, 4 ounces. With sparks. Mealed powder, 1 ounce; saltpetre, 1 ounce; camphor, 2 ounces. Other receipts for stars suitable for rocket garniture will be found under the head of "Colored Fires." (*See No.* 2065, *&c.*)

2059. To Prepare Touch Paper. Soak unglazed paper in a solution of nitre in vinegar or water. The stronger the solution, the faster will it burn. A good plan is to dip it in a weak solution, dry it, try it, and if it burns too slowly, make the solution stronger and dip it again to make it burn faster.

2060. To Make Quick Match. Quick match is made by immersing lamp-wick in a solution of saltpetre with meal powder, winding it on a frame, and afterwards dusting with meal powder. To 28 ounces cotton, take saltpetre, 1 pound; alcohol, 2 quarts; water, 3 quarts; solution of isinglass (1 ounce to the pint), 3 gallons; mealed powder, 10 pounds.

2061. Inextinguishable Match. Take 4 parts dry nitre, 2 gunpowder, 2 charcoal, and 1 sulphur, and mix them; then ram the compound into paper cases 9 inches in length and of the thickness of a common quill. When this composition is inflamed, rain will not extinguish it; the burning end of the match must be cut off to stay the fire.

2062. To Make Roman Candles. The cases for Roman candles are not choked, but well secured at the bottom with clay. A small charge of gunpowder is first introduced, then a star, followed by a charge of composition (*see No.* 2063); these are gently rammed down, and the same routine of gunpowder, star, and composition, is repeated until the case is full. Lastly, prime and close with touch paper. The stars are flat cylinders of a paste composition, cut to fit the bore of the case, and having a hole bored in their centre to allow the fire to pass through to the charge behind them. The stars which are nearest to the mouth of the case should fit a little tightly, and gradually a little more loosely as they are further from the mouth. The charges of powder behind them should also decrease by degrees as their position is further from the mouth of the case. It is also advisable to put a loose wad of one thickness of paper, with a hole in the centre, between each star and the gunpowder behind it.

2063. Composition for Roman Candles. Mix ½ pound meal-powder, 2½ pounds saltpetre, and ½ pound each sulphur and glass dust.

2064. Colored Stars may be made by using any of the receipts for colored fires, with a solution of isinglass, ½ ounce; camphor, ¼ ounce; and alcohol, ¾ ounce. Make into cylindrical cakes of the requisite size, punch a hole in the centre of each, roll in gunpowder, and dry in the sun.

2065. Colored Fires. Great care is necessary in the preparation of these combustibles. The ingredients should be *separately* reduced to powder and sifted; then put into well-corked, wide-mouthed bottles until the time for mixing them for use. Colored fires deteriorate rapidly by keeping, and are nearly all dangerously inflammable; they should, therefore, be mixed as soon as possible - before using them. The ingredients should be pure and perfectly dry; uniformly powdered, but not so fine as to be dusty. Nitrate of strontia, alum, carbonate of soda, and other crystals, should be gently heated in an iron pan until they lose their water of crystallization and crumble into dry powder. (*See Drying, No.* 3842.) Chlorate of potassa must be *very cautiously* handled, as it explodes by moderate friction. The requisite quantity of each ingredient should be weighed and placed on a clean sheet of white paper, and mixed lightly with a bone knife; they may then be more thoroughly mixed by sifting through a fine wire seive.

2066. Colored Fires for Illuminations. Pack the compounds lightly into small cups or pans.

2067. Colored Fires for Stars, &c. The compounds may be put into small pill-boxes, with a little priming and a quick match (*see No.* 2060) attached to each. If kept, they should be put where no damage can happen in case of their catching fire.

2068. To Make Colored Fires. The following receipts for the preparation of these effective aids in pyrotechnic and dramatic display, are among the very best that are known. These fires have in some theatres been assisted, if not superseded, by the calcium light; color being communicated by passing the rays of light through colored glass. The unpleasant smell of colored fires is avoided, and the effects can be prolonged at pleasure, instead of lasting merely a few moments.

2069. Blue Fire. Mix 2 parts realgar (red arsenic), 3 parts charcoal, 5 parts chlorate of potassa, 13 parts sulphur, and 77 parts nitrate of baryta.

2070. Bird's Blue Fire. 1 part charcoal, 1 part orpiment (yellow sulphuret of arsenic), 16 parts black sulphuret of antimony, 48 parts nitre, and 64 parts sulphur.

2071. Bengal, or Blue Signal Light, used at Sea. 1 part tersulphide of antimony, 2 parts sulphur, and 6 parts dry nitre. (*See No.* 2065.)

2072. Bengal Lights. Braunschweizer recommends the following mixtures as not producing injurious fumes: For red lights: 9 parts nitrate of strontia, 3 parts shellac, 1½ parts chlorate of potassa. For green: 9 parts nitrate of baryta, 3 parts of shellac, 1½ parts chlorate of potassa. For blue: 8 parts ammoniacal sulphate of copper, 6 parts chlorate of potassa, 1 part of shellac.

2073. Blue Fire for Stage Effect. 15 parts of sulphur, 15 parts sulphate of potassa, 15 parts ammonio-sulphate of copper, 27 parts nitre, and 28 parts chlorate of potassa. The blue is made darker or lighter by increasing or diminishing the potassa and copper ingredients. This is Marchand's preparation.

2074. Marsh's Blue Fire. Mix 7 parts sulphate of copper, 24 sulphur, and 69 parts chlorate of potassa.

2075. Marsh's Crimson Fire for Pots. Mix 17 parts chlorate of potassa, 23 willow charcoal, 90 parts sulphur, and 270 parts nitrate of strontia.

2076. Marsh's Crimson Fire for Stars and Boxes. Mix 17 parts charcoal, 22 parts sulphuret of antimony, 69 chlorate of potassa, 72 parts sulphur, and 220 parts nitrate of strontia.

2077. Marchand's Purple Crimson Fire. Mix 16 parts sulphur, 23 parts dry chalk, 61 parts chlorate of potassa.

2078. Green Fire for Ghost Scenes. Equal parts charcoal and nitrate of baryta.

2079. Brilliant Green Fire. A magnificent green fire can be prepared by mixing 6 parts chlorate of thallium, 2 parts calomel, and 1 part resin.

2080. Green Fire. Take 2 parts metallic arsenic, 3 parts charcoal, 5 parts chlorate of potassa, 13 parts sulphur, 77 parts nitrate of baryta. This is a beautiful fire, particularly when burnt before a reflector of glass or metal.

2081. Marchand's Green Fire. Mix 10 parts boracic acid, 17 sulphur, and 73 parts chlorate of potassa.

2082. Green Fire for Theatrical Tableaux. Take 18 parts chlorate of potassa, 22 parts sulphur, 60 parts nitrate of baryta.

2083. Light Green Fire. Mix 16 parts sulphur, 24 carbonate of baryta, 60 parts chlorate of potassa.

2084. Green Fire for Pots or Stars. Take 7 parts charcoal, 7 sulphuret of arsenic, 42 parts sulphur, 93 parts chlorate of potassa, 250 parts nitrate of baryta.

2085. Lilac Fire for Pans. Take 6 parts black oxide of copper, 20 dry chalk, 25 parts sulphur, 49 parts chlorate of potassa.

2086. Lilac Fire for Stars. Take 3 parts black oxide of copper, 22 parts dried chalk, 25 parts sulphur, 50 chlorate of potassa.

2087. Red Fire. Mix 16 parts sulphur, 23 parts carbonate of strontia, 61 parts chlorate of potassa.

2088. Red Fire for Stage Effect. Mix 20 parts chlorate of potassa, 24 sulphur, 56 parts nitrate of strontia.

2089. Orange Red Fire. Take 14 parts sulphur, 34 chalk, 52 parts chlorate of potassa.

2090. Purple Red Fire. Sulphur, 16 parts, 23 parts chalk, 61 parts chlorate of potassa.

2091. Purple Fire. Take 1 part each of lampblack, red arsenic, and nitre; 2 parts sulphur, 5 parts chlorate of potassa, and 16 parts fused nitrate of strontia.

2092. Pink Fire for the Stage. Mix 1 part charcoal, 20 chalk, 20 parts sulphur, 27 parts chlorate of potassa, 32 parts nitre.

2093. Rose Colored Fire. Take 16 parts sulphur, 23 dried chloride of calcium, 61 parts chlorate of potassa.

2094. Pale Violet Fire. Take 14 parts sulphur, 16 parts alum, 16 carbonate of potassa, 54 parts chlorate of potassa.

2095. Dark Violet Fire. Take 12 parts alum, 12 parts carbonate of potassa, 16 parts sulphur, 60 parts chlorate of potassa.

2096. White Fire for Theatres. Take 2 parts charcoal, 22 sulphur, 76 parts nitre.

2097. White Fire for Pans or Stars. Take 60 parts nitre, 20 parts sulphur, 10 black antimony, 4 parts powdered camphor, 6 parts meal powder.

2098. Marsh's White Fire for Pans. Take 25 parts gunpowder, 36 zinc filings, 46 parts sulphur, 93 parts nitre.

2099. Yellow Fire. Take 16 parts sulphur, 23 parts dried (*See No.* 2065) carbonate of soda, 61 chlorate of potassa.

2100. Marsh's Yellow Fire. Mix 12 parts charcoal, 149 parts dry (*see No.* 2065) nitrate of soda, 39 parts sulphur.

2101. Fire-eating Ghosts. Pour some strong warm spirits into a flat dish, sprinkle some salt into it, and set it on fire on a table in a perfectly dark room, taking care to protect the table from injury. Persons standing round the table will appear of a deathly pallor, and by eating raisins dipped in the burning spirit, will appear to eat fire. Shutting the mouth quickly on the burning raisins, extinguishes them instantly.

2102. Port Fire. The port fire used for cannon is composed of 3 parts nitre, 9 sulphur, and 1 gunpowder, well mixed and rammed into cases. These are also useful for igniting fireworks.

2103. Signal Lights. Such lights are generally composed of sulphur and nitre, with a small quantity of metallic sulphuret. Mix 600 grains nitre, 2 sulphur, and 100 yellow sulphuret of arsenic, and ram it into a conical paper case. When touched with a red-hot iron it deflagrates rapidly with a brilliant white light. The sulphuret of antimony may be substituted for that of arsenic.

2104. Indian White Fire Signal. Dry (*see No.* 2065) nitre, 24 parts; sulphur, 7 parts; powdered charcoal, 1; or instead of the charcoal, 2 parts red sulphuret of arsenic. Mix them intimately in an iron vessel, and ram the mixture into thick paper cylinders of about 3 inches in length by 1 in diameter. These are kept in a dry place, and when one is required to be used, it is set on end, and a piece of red-hot charcoal placed upon it.

2105. Iron Sand for Fireworks. Used to give corruscations in fireworks, is far better than iron or steel-filings. It is made by beating cast steel or iron into small pieces on an anvil. These are sifted into 4 sizes, the smallest for the smallest pieces, and vice versa. The corruscations produced by these are exceedingly brilliant. The sand should be kept in a dry place in a well-closed bottle, as any rust damages it. Fireworks containing it should not be made very long before using.

2106. Open Fires. The following article and receipts for open fires are by Professor Ferrum, and we quote them from the "American Druggists' Circular":

Among the many receipts for open fires, but few deserve to be recommended, and these have been selected. The white and red fires only show a clear, distinct color. The green is generally pale, and shows off only when burnt after a red. A pure blue is very difficult to obtain. The following should be observed as general rules: The ingredients for the fires are dried singly at a slightly elevated temperature, finely powdered, and preserved in well-stoppered bottles, until required for use The mixing of the ingredients is best performed on a sheet of paper by means of a card, and should be done very carefully so as to ensure a complete mixture. Sifting is in most cases admissible, while triturating in a mortar is above all to be avoided. After mixing, the powder is piled in small heaps in open vessels, for which purpose small flower-pots or flower-pot dishes are well adapted. On top of these several piles, some gunpowder is placed to facilitate the lighting. The vessels should be arranged in such a manner that the flame may illuminate the intended object without being seen by the spectators. The distribution of the material into a greater or less number of dishes is governed by circumstances. A great number of small flames from a certain quantity of mixture generally give a more intense, but so much shorter-lived light than the same quantity distributed in larger portions; beyond a certain limit, however, even that intensity is not materially heightened by a few more lights. If the fire is to continue for some time, it must further be considered that large quantities of the mixture form a correspondingly greater amount of slags, which greatly mar the effect. It is therefore, best in such cases to burn off a number of small charges successively.

2107. White Fire. The following mixture we recommend as the very best for white lights, being unsurpassed in brilliancy and power by any other:

Saltpetre, 18 parts; sulphur, 10 parts; black sulphuret of antimony, 3 parts; burnt lime, 4 parts. The sulphur is used in the form of flowers previously dried; the lime is not to be slacked, but must be finely powdered; it must be fresh, and be powdered immediately before use. All other mixtures for white fires have either a bluish tinge or contain deleterious ingredients, which render them at least unsuitable for indoor use. Of the latter class we will mention only one: Saltpetre, 12 parts; sulphur, 4 parts; sulphite of tin, 1 part. Two other mixtures deserve mention, though not equal to the last:

I. Saltpetre, 48 parts; sulphur, 13¼ parts; sulphide of sodium, 7¼ parts; and

II. Saltpetre, 64 parts; sulphur, 21 parts: gunpowder, 15 parts.

2108. Blue Fire. The only mixture to be relied on, though the light is not purely blue, but bluish white, is the following: Saltpetre, 12 parts; sulphur, 4 parts; black sulphuret of antimony, 1 part.

2109. Red Fire. The following mixture is the best in use; its composition may be altered by various admixtures:

I. Nitrate of strontia, 13 parts; sulphur, 1 part; powder dust, 1 part. The latter ingredient is prepared from fine gunpowder, rubbed up carefully in a mortar and then sifted through a hair sieve. Another receipt is:

II. Nitrate of strontia, 24 parts; chlorate of potassa, 16 parts; stearine, 4 parts; powdered charcoal, 1 part. In using chlorate of potassa the precautions given in No. 2124 must be strictly observed, and all pounding and rubbing avoided.

III. Nitrate of strontia, 20 parts; chlorate of potassa, 4 parts; sulphur, 5 parts; black sulphuret of antimony, 2 parts; powdered charcoal, 1 part. Gives a very strong light.

The nitrate of strontia for these fires, as the ingredients for all others, must be well, but carefully dried. (*See No.* 2065.)

2110. Yellow Fire. This color, which is very little used, is produced by the following mixture: Nitrate of soda, 48 parts; sulphur, 16 parts; black sulphuret of antimony, 4 parts; powdered charcoal, 1 part.

2111. Green Fires. The coloring ingredients for these lights are the salts of baryta. The color is generally not very deep.

I. Nitrate of baryta, 45 parts; sulphur, 10 parts; chlorate of potassa, 20 parts; calomel, 2 parts; lampblack, 1 part.

II. Nitrate of baryta, 60 parts; chlorate of potassa, 18 parts; sulphur, 22 parts.

III. Chlorate of baryta, 3 parts; sulphur, 1 part.

IV. Chlorate of baryta, 24 parts; stearin, 3 parts; sugar of milk, 1 part.

V. Chlorate of baryta, 3 parts; sugar of milk, 1 part.

2112. Colored Lights. We derive the receipts for these from the same source as the open fires. (*See No.* 2106.) Colored lights are formed by filling cylinders of thin writing paper of about an inch in diameter with the mixtures. The length of the cylinder determines the duration of the light. The mixtures may be moistened and pounded into the cylinder with a wooden rod; after drying, they will then be hard enough to allow of the removal of the paper, and may be further strengthened by being dipped in or painted over with mucilage of gum-arabic. The cylinders, when finished, are tied to the upper end of sticks fastened in the ground in a vertical position. The mixtures vary essentially from those used for colored fires.

2113. White Lights. Saltpetre, 4 parts; sulphur, 1 part; black sulphuret of antimony, 1 part.

2114. Yellow Lights. I. Black sulphuret of antimony, 2 parts; chlorate of potassa, 4 parts; sulphur, 2 parts; oxalate of soda, 1 part.

II. Saltpetre, 140 parts; sulphur, 45 parts; oxalate of soda, 30 parts; lampblack, 1 part.

2115. Green Lights. I. Chlorate of baryta, 2 parts; nitrate of baryta, 3 parts; sulphur, 1 part.

II. Chlorate of potassa, 20 parts; nitrate of baryta, 21 parts; sulphur, 11 parts.

2116. Red Lights. Nitrate of strontia, 25 parts; chlorate of potassa. 15 parts; sulphur, 13 parts; black sulphuret of antimony, 4 parts; mastich, 1 part.

2117. Pink Lights. Chlorate of potassa, 12 parts; saltpetre, 5 parts; sugar of milk, 4 parts; lycopodium, 1 part; oxalate of strontia, 1 part.

2118. Blue Lights. Chlorate of potassa, 3 parts; sulphur, 1 part; ammoniated copper, 1 part.

2119. Colored Lights without Sulphur—For Indoor Illuminations. These are used for the purpose of lighting up tableaux vivants, and for private theatricals.

2120. White Light. Chlorate of potassa, 12 parts; saltpetre, 4 parts; sugar of milk, 4 parts; lycopodium, 1 part; carbonate of baryta, 1 part.

2121. Yellow Light. Chlorate of potassa, 6 parts (or nitrate of baryta 10 parts); saltpetre, 6 parts; oxalate of soda, 5 parts; powdered shellac, 3 parts.

2122. Green Light. Only after yellow or red lights. Chlorate of potassa, 2 parts; nitrate of baryta, 1 part; sugar of milk, 1 part.

2123. Red Light. Nitrate of strontia, 12 parts; chlorate of potassa, 8 parts; sugar of milk, 1 part; stearine, 2 parts.

2124. Caution in the Use of Chlorate of Potassa. This substance should never be kept in admixture with any inflammable matter, especially sulphur or phosphorus, as they explode with terrific violence by the most trivial causes, and not unfrequently spontaneously. All pounding and rubbing must be avoided.

2125. Paper for Producing Flashes of Colored Light. Soak unsized paper for ten minutes in a mixture of 4 parts, by measure, oil of vitriol, and 5 parts strong fuming nitric acid; wash out thoroughly in warm distilled water, and dry it thoroughly at a gentle heat. The paper thus prepared is similar in its properties to gun cotton, and a small pellet of it, lighted at one point at a flame, and then thrown into the air, will produce a brilliant flash, and leave no perceptible ash. The color is given by saturating the gun-paper in the one of the solutions given below and then drying it.

A solution of chlorate of strontium makes the flash a bright crimson. Chlorate of barium, green. Nitrate of potassium, violet. Chlorate of copper, blue. Any one of the foregoing chlorates may be prepared by mixing a warm solution of the corresponding chloride with an equivalent quantity of a warm solution of chlorate of potassa; the precipitate formed will be chloride of potassium, and the clear liquid, poured off, will be the desired chlorate, to be used for saturating the gun-paper.

2126. Japanese Matches. Lampblack, 5 parts; sulphur, 11 parts; gunpowder, from 26 to 30 parts, this last proportion varying with the quality of the powder. Grind very fine, and make the material into a paste with alcohol; form it into dice, with a knife or spatula, about ¼ inch square; let them dry rather gradually on a warm mantel-piece, not too near a fire. When dry, fix one of the little squares in a small cleft made at the end of a stalk of broom-corn. Light the material at a candle, hold the stem downward, and await the result. After the first blazing off, a ball of molten lava will form, from which the curious corruscations will soon appear.

2127. Japanese Firework Mixture. Finely pulverized nitrate of potassa, 70 parts; washed flowers of sulphur, 30 parts; powdered lycopodium, 12 parts; best and very light lampblack, 8 parts. From 1½ to 2 grains of this powder are sufficient for use packed in strips of suitable paper.

2128. Colored Flames. The flame of alcohol may be colored by mixing certain salts with the spirit. A green color is given by muriate of copper, or boracic acid. Red, by nitrate of strontian, nitrate of iron, or nitrate of lime. Yellow, by nitrate of soda, &c.

2129. Greek Fire. True Greek fire is simply a solid, highly combustible composition, consisting of sulphur and phosphorus dissolved in the bisulphide of carbon, to which occasionally some mineral oil is added, with the view of increasing its incendiary powers. When the liquid is thrown on any surface exposed to the air the solvent evaporates, leaving a film of the phosphorus or sulphide of phosphorus, which then inflames spontaneously. The proper mode of extinguishing such a fire is to throw damp sand, ashes, sawdust, lime, or any powder, wet sacking or carpeting, in short, any material which will exclude the air from the fire. No attempt should be made to remove the covering for some time after the flame has been extinguished. The place should afterward be thoroughly washed by a powerful jet of water forced upon it.

Explosives. This is a general term for all substances which explode with violence. Some of these, as gunpowder, gun-cotton, &c., explode by being brought into contact with fire. Others, to which the term of *Fulminates* is applied, explode with violence by slight heat, friction, or concussion.

2131. Fulminating Antimony. Grind well together 100 parts of dried tartar emetic, and 3 parts of lampblack, or charcoal powder; then take a crucible capable of holding 3 ounces of water, and having ground its edge smooth, and rubbed the inside with powdered charcoal, ½ fill it with the above mixture, cover it with a layer of charcoal powder, and lute on the cover. Expose it for 3 hours to a strong heat in a reverberatory furnace, and, when taken out, let it stand to cool for 6 or 7 hours before removing its contents, to prevent an explosion. The crucible being now opened, the contents must be hastily transferred, without breaking, to a wide-mouthed stoppered phial, when, after some time, it will crumble down into a powder of itself. Or: Triturate together, very carefully, 100 parts antimony, 75 parts carburetted (roasted to blackness) cream of tartar, and 12 parts lampblack; preserve it in phials. When the above processes are properly conducted, the resulting powders fulminate violently on contact with water. It is to the presence of the very inflammable metal potassium that they owe this property. Another compound, made with 60 parts of carburetted cream of tartar, 120 bismuth, and 1 of nitre, treated as above, contains an alloy very rich in potassium. A piece the size of a pea introduced into a mass of gunpowder explodes it on being thrown into water.

2132. Fulminating Gold. Dissolve gold in aqua regia (made by dissolving 4 ounces sal ammoniac in 12 or 16 ounces nitric acid), and precipitate with a solution of carbonate of potassa. Fulminating gold should be made in very small quantities at a time, to avoid risk, as without great care it explodes with extreme violence. This is caused by the slightest friction or sudden increase of heat. Its fulminating property may be destroyed by boiling it in pearlash lye, or oil of vitriol; and by heating the powder after washing it in water, pure gold will be obtained.

2133. Fulminating Silver. Digest oxide of silver (recently precipitated, and dried by pressure between bibulous paper) in concentrated liquor of ammonia for 12 or 15 hours, pour off the liquid, and cautiously dry the black powder in the air. The decanted ammonia, when gently heated, yields, on cooling, small crystals, which possess a still more formidable power of detonation, and will scarcely bear touching, even while under the liquid. This compound is exploded by the slightest friction or percussion, and should therefore be only made in very small quantities at a time, and handled with great caution. Its explosive powers are tremendous; in fact, it can hardly be handled with safety, even in the moist state. Many frightful accidents have happened from the spontaneous explosion of this substance. At most 1 or 2 grains can be exploded with safety at one time.

2134. Fulminating Mercury. Dissolve by a gentle heat 100 parts, by weight, of mercury in 100 parts nitric acid of specific gravity 1.4; and when the solution has acquired a temperature of 130° Fahr., slowly pour it through a glass funnel tube into 830 parts alcohol of specific gravity .830. As soon as the effervescence is over and white fumes cease to rise, filter it through double paper, wash with cold water, and dry by steam (not hotter than 212°) or hot water. This is the formula of Dr. Ure, and said to be the cheapest and safest. If parts by measure be adopted, the above proportions will be, for 100 parts, by measure, of mercury, 740 parts nitric acid, and 830 parts alcohol.

2135. Fulminating Copper. Digest copper, in powder or filings, with fulminate of mercury or of silver, and a little water. It forms soluble green crystals that explode with a green flame.

2136. Fulminating Powder. Powder *separately* 3 parts nitre, 2 parts dry (*see No.* 2065) carbonate of potash, and 1 flowers of sulphur; mix them together carefully. If 20 grains of this compound are slowly heated on a shovel over the fire, it melts and becomes brown, exploding with a loud report.

2137. New Explosive Compound. B. G. Amend has observed that glycerine mixed with crystallized permanganate of potassa in a mortar spontaneously deflagrates.

2138. Priming for Percussion Caps. To make this compound 100 grains of fulminating mercury are triturated with a wooden muller on marble, with 30 grains of water and 60 grains of gunpowder. This is sufficient for 400 caps. Dr. Ure recommends a solution of gum mastich in turpentine as a medium for attaching the fulminate to the cap.

2139. Percussion Pellets. Mix equal parts of the chlorate of potassa and sulphuret of antimony with liquid gum, so as to form a paste. When dry it may be formed into pellets, and used as percussion powder for guns. This composition, placed on the ends of splints dipped in sulphur, produces friction matches. This mixture may also be employed for percussion caps, only without the gum; the two substances, mixed together dry, are forced into the caps, and a drop of varnish deposited on the inside surface of each. A mixture of the fulminate of mercury, chlorate of potassa, and sulphur, however, is more commonly used for lining percussion caps.

2140. To Make Gunpowder. Pulverize separately, 76 parts nitrate of potassa, 11 sulphur, and 13 freshly burned charcoal, and mix them with a little water, so as to form a cake when rolled out on a board. This is then dried on a clean sheet of paper placed in a warm situation, and afterwards crumbled into grains. It will form unglazed gunpowder. The pulverized ingredients, thoroughly mixed, without the addition of any water, constitute what is called *meal powder;* this may also be made by pulverizing grained gunpowder very cautiously in a mortar, or with a muller. (*See Porphyrization, No.* 25.)

2141. To Prepare Gun-Cotton. The simplest way consists in immersing, for a few seconds, well-carded cotton in a mixture of equal parts, by volume, of oil of vitriol of specific gravity 1.845, and nitric acid of specific gravity of 1.500. The cotton, when well saturated, is to be removed and squeezed to repel the excess of acid, and then well washed in clean cold water, until the water no longer reddens litmus paper. It is then dried at a heat not exceeding 212°. A lower temperature is still safer. The cotton thus prepared explodes well, but does not dissolve easily in ether. Under *Collodion* will be found other preparations of Gun-Cotton.

2142. Nitro-glycerine. This is an oily, colorless liquid, with a specific gravity of 1.60. It has no smell, but a taste which at first is sweet, but soon becomes pungent, like pepper; is soluble in ether and methylic alcohol, but not in water, but the presence of water diminishes the risk of explosion. It begins to evaporate at 365° Fahr. It has been found that pure nitro-glycerine, dropped upon a thoroughly red hot iron, assumes a spheroidal state and flashes off into vapor in the same way as gunpowder; but if the iron is not red hot, only hot enough to cause the nitro-glycerine to boil suddenly, a frightful explosion takes place. The explosion of a single drop in this manner will cause serious damage. This dangerous compound requires most careful handling, a slight shock sometimes exploding it.

2143. To Prepare Nitro-glycerine. Mix 100 parts fuming nitric acid at 50° Baumé with 200 parts sulphuric acid; when cool, add 38 parts glycerine slowly, allowing it to trickle down the sides of the vessel. The glycerine will remain on the surface for hours without mixing. Stir the glycerine and acids with a glass rod for 10 seconds, pour it into 20 times its volume of water, and the nitro-glycerine will be instantly precipitated to the extent of 76 parts, or double the amount of glycerine employed. It must be repeatedly washed with water, and then saturated with bicarbonate of soda or lime.

2144. Blasting Powders. Neither fresh nor salt water has any injurious effect on blasting powders; they need only to be dried to regain their explosive character. Their emitting but little smoke renders them useful in underground operations, and their explosive force is eight times that of gunpowder. They explode with extreme facility, either by contact with a strong acid, a slight elevation of temperature, or the slightest friction. In preparing them, therefore, excessive precaution is necessary, especially in mixing the ingredients. A straw, slightly wetted with oil of vitriol, applied to a small heap of the powder, will cause instantaneous explosion.

2145. To Make Blasting Powder. Reduce *separately* to powder, 2 parts chlorate of potassa and 1 part red sulphuret of arsenic; mix very lightly together. Or:—Powder separately, 5 parts chlorate of potassa, 2 parts red sulphuret of arsenic, and 1 part ferrocyanide of potassium (prussiate of potassa); mix carefully. Or:—Mix carefully, as before, after having separately reduced to powder, equal parts chlorate of potassa and ferrocyanide of potassium.

2146. Parlor or Congreve Matches. Dissolve 16 parts gum-arabic in the least possible quantity of water, and mix with it 9 parts phosphorus in powder (*see No.* 4338); then add 14 parts nitre (saltpetre), and 16 parts of either vermilion (red sulphuret of mercury), or binoxide (black oxide) of manganese, and form the whole into a paste. Dip the matches into this paste, and then let them dry. When quite dry they are to be dipped into a very dilute copal or lac varnish, and again dried; by this means they are less likely to suffer from damp weather.

2147. Cheap Parlor Matches. A cheaper paste for dipping may be made by soaking 6 parts glue for 24 hours in a little water, and liquefied by rubbing in a heated mortar; 4 parts phosphorus are next added at a heat not exceeding 150° Fahr.; then add 10 parts finely powdered saltpetre; and lastly 5 parts red lead and 2 parts smalts are mixed in, the whole being formed into a uniform paste. The matches are dipped, dried, varnished, and dried again, as before.

2148. To Make Matches Without Sulphur. To obviate the use of sulphur for igniting the wood of the match, the ends of the matches are first slightly charred by rubbing them against a red hot iron plate, and then dipped into as much white wax, melted in a suitable vessel, as will cover the bottom about ⅛ inch in depth. Or they may be dipped into camphorated spirit. Or into a solution of 1 ounce Venice turpentine and ½ ounce camphor, in ¼ pint oil of turpentine, with a little gum-benzoin and cascarilla by way of perfume. After any of the above preparations the matches are ready for dipping in the phosphorus paste.

2149. Substitute for Lucifer Matches. The dangers arising from the universal adoption of the common lucifer match have induced chemists to seek a substitute for it. M. Peltzer has recently proposed a compound which is obtained in the shape of a violet powder, by mixing together equal volumes of solutions of sulphate of copper, one of which is supersaturated with ammonia, and the other with hyposulphite of soda. A mixture of chlorate of potash and the above powder will catch fire by percussion or rubbing; it burns like gunpowder, and leaves a black residue. M. Viederbold proposes a mixture of hyposulphite of lead, or baryta, or chlorate of potash, for matches without phosphorus. The only inconvenience of this compound is that it attracts moisture too easily.

2150. Mixtures for Matches. For sulphur dips: Phosphorus, 3 parts; glue, 6 parts; sand, 1 part; incorporated below 100° Fahr., with 10 parts of water. Or, phosphorus, 5 parts; fine sand, 4 parts; red ochre, 1 part (or, ultramarine), ½ part; gum-arabic, 5 parts, in 6 pints of water (or, 4 parts of glue in 9 parts of water). For stearine dips: Phosphorus, 3 parts; brown oxide of lead, 2 parts; turpentine, ½ part, softened in 3 parts water. Instead of the brown oxide, 2 parts of red lead stirred up with ½ part of nitric acid may be used.

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for

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FIREWORKS.

Bengal Lights. Besides the combustible and coloring components, the fireworks known under this name contain substances which, by yielding oxygen, aid combustion. The principal ingredients used for this purpose are charcoal, lampblack, sulphur, stearine, linseed oil, colophony, sugar, etc. For coloring the lights the following substances are made use of: Sulphide of antimony, arsenical sulphides, nitrate of barium, nitrate of strontium, sulphate of potassium, carbonate of sodium, cupric oxide, boracic acid, chlorate of potassium, saltpetre, etc. In preparing colored lights the greatest attention should be paid to the absolute purity of the ingredients used, and that they are powdered as finely as possible and very intimately mixed with a spatula after pulverization. Every mixture containing chlorate of potassium must be treated and handled with the utmost care and caution, as such mixtures are liable to spontaneous ignition and even to explosion. For preparing a very fine powder of it, it is best to allow a supersaturated hot solution of chlorate of potassium to become cold, with constant stirring, when the salt will be separated in the form of a very fine crystallized flour, which should be dried without exposing it to direct heat. To secure uniformity the ready mixtures should be sifted. It is advisable to use dry materials only in manufacturing them, not to prepare large quantities at one time, and to store the mixtures in a dry place in hermetically closed vessels.

Colored lights are best used by pressing the mixture into cases (cartridges) of paper twice as long as wide and igniting it by means of a quick match.

Quick Matches are made of 4 parts of saltpetre, 2 of gunpowder, 2 of charcoal, and 1 of sulphur. Quick matches made of this composition never miss fire and are not extinguished by rain or wind.

White Fire. This excellent light, on account of its brilliant whiteness, is especially adapted for night signalling and also for festive occasions. It is produced by mixing 24 parts of saltpetre, 7 of flowers of sulphur, and 2 of realgar.

In mixing the saltpetre with the flowers of sulphur sulphurous vapors are developed which form moist lumps in the mass. To secure a good ignition and quick combustion of the mass it is necessary to dry it thoroughly in an iron pan with gentle heat, as, if this precaution is neglected, it frequently misses fire or ignites and then goes out. The mixture is cheaper than gunpowder, as less labor is required in preparing it and very little danger incurred.

Mohr's White Fire, which is very effective and scarcely ever misses fire, is composed of 24 parts of saltpetre, 7 of sulphur, and 1 of fine charcoal. The charcoal increases the inflammability of the mixture and shortens the length of time during which the light burns, but adds to its intensity. It is not permissible to use a larger amount of charcoal than that given, as the composition would then approach that of gunpowder.

White Fire for Theatres, etc. I. Forty-eight parts of saltpetre, 13.25 of sulphur, 7.25 of sulphide of antimony.

II. Twelve parts of saltpetre, 4 of sulphur, 1 of sulphide of sodium.

III. Sixteen parts of saltpetre, 12 of mealed powder, 12 of cast-iron filings, 8 of powdered charcoal.

IV. One part of charcoal, 3 of sulphur, 7 of saltpetre, 1 of chlorate of potassium, 4 of sulphide of antimony.

V. Thirty-two parts of saltpetre, 12 of sulphur, 8 of sulphide of sodium, 1 of gunpowder.

VI. One hundred to 133 parts of pulverized antimony, 48 to 206 of pulverized sulphur, 375 to 500 of saltpetre.

VII. Sixty-four parts of pulverized saltpetre, 21 of pulverized sulphur, 15 of gunpowder.

VIII. One hundred parts of potassium carbonate, 10 of sulphide of antimony, 15 of boiled linseed oil.

IX. Eleven parts of chlorate of potassium, 4 of nitrate of potassium, 1 of stearine, 1 of carbonate of barium, 5 of milk sugar.

X. Forty-five parts of sulphide of antimony, 15 of washed flowers of sulphur, 96 of saltpetre, 15 of stearine.

The stearine is either grated or cut in shavings and then rubbed with some pulverized saltpetre into as fine a powder as possible. The other powdered ingredients are then mixed with it and the mixture passed through a fine sieve.

XI. Eighteen parts of saltpetre, 3 of sulphide of antimony, 10 of sulphur, 4 of burned lime (unslaked).

Greenish-white Fire. I. Two parts of sulphur, 1 of oxide of zinc, 2 of sulphide of antimony, 1 of powdered charcoal.

II. Fifty parts of saltpetre, 25 of sulphur, 5 of sulphide of antimony, and 0.5 of alum.

Bluish-white Fire. Uhden has made experiments in regard to the availability of sulphide of cadmium for pyrotechnic purposes. In the following mixture the sulphide of cadmium burns with a brilliant white flame surrounded with a magnificent blue border: Mix 20 parts of saltpetre, 4 of sulphide of cadmium, 5 of sulphur, and 1 of pulverized charcoal. This mixture may be used for fire-balls.

Red Fire. I. Forty parts of nitrate of strontium, 15 of sulphur, 5 of chlorate of potassium, and 2 of charcoal.

II. Fifty parts of chlorate of potassium, 50 of nitrate of strontium, 5 of charcoal, and a sufficient quantity of linseed oil to knead the mass together.

Red Fire according to Braunschweiger. Nine parts of nitrate of strontium, 3 of shellac, 1.5 of chlorate of potassium. The shellac need only be coarsely powdered. The above 3 mixtures for red fire possess the advantage of not emitting injurious vapors, and can therefore be used in rooms, etc.

Holtz's Red Fire, which was so much used in Berlin during the festivities in celebration of the victories in the French war, contains no chlorate of potassium, but is simply composed of 1 part of shellac and 4 of nitrate of strontium. The absence of chlorate of potassium makes it possible to store such mixtures without any danger, though the light produced is less intense and brilliant in color. The mixture is not very inflammable, burns better if slightly moistened, develops but little smoke, and, as it burns very slowly, is without doubt the cheapest material for red lights. A very small addition of chlorate of potassium improves the color of the flame very much.

Receipts for other Red-fire Mixtures. I. Fifty-six parts of nitrate of strontium, 24 of sulphur, 20 of chlorate of potassium.

II. Twenty-three parts of carbonate of strontium, 16 of sulphur, 61 of chlorate of potassium.

III. Mix 40 parts of pulverized nitrate of strontium, 6 of pulverized chlorate of potassium, 13 of washed flowers of sulphur, and 2 of pulverized charcoal.

Instead of the rather expensive precipitated chalk, salts of strontia, carbonate of calcium, and the native sulphate of strontium (coelestine), may be used for preparing red fire according to the following receipts:

I. Mix carefully 3 parts of powdered coelestine, 2 of sulphur, and 5 of chlorate of potassium.

II. Three parts of precipitated chalk, 2 of sulphur, 6 to 8 of chlorate of potassium.

III. Twelve hundred and fifty parts of sulphate of strontium, 375 of purified sulphur, 166 of chlorate of potassium, and 133 of antimony.

IV. Seven hundred and fifty parts of carbonate of strontium, 500 of purified sulphur, 1750 of chlorate of potassium.

V. Rub fine and mix 195 parts of nitrate of strontium, 45 of chlorate of potassium, 45 of washed flowers of sulphur, 7.5 of powdered charcoal, and 22.5 of stearine.

VI. Eleven parts of chlorate of potassium, 4 of nitrate of potassium, 5 of milk sugar, 1 of earth-moss seed, 1 of oxalate of strontium.

Purple Fire. Powder and mix 61 parts of chlorate of potassium, 16 of sulphur, 23 of chalk.

Rose-red Light. I. Rub fine and mix 61 parts of chlorate of potassium, 16 of sulphur, 23 of chloride of potassium.

II. Pulverize and mix 20 parts of sulphur, 32 of saltpetre, 27 of chlorate of potassium, 20 of chalk, 1 of charcoal.

Red-orange Fire. Pulverize and mix 52 parts of chlorate of potassium, 14 of sulphur, 34 of chalk.

Dark-violet Fire. Rub fine and mix 60 parts of chlorate of potassium, 16 of sulphur, 12 of carbonate of potassium, and 12 of alum.

Pale-violet Fire. Rub fine and mix 54 parts of chlorate of potassium, 14 of sulphur, 16 of carbonate of potassium, and 16 of alum.

Blue Fire. I. Eighteen parts of chlorate of potassium, 24 of saltpetre, 14 of sulphur, 6 of cupric oxide.

II. Four parts of mealed gunpowder, 3 of sulphur, 3 of powdered zinc, 2 of saltpetre.

III. The following mixture gives a loudly detonating compound: Two parts of saltpetre, 1 of sulphur, 2 of carbonate of potassium, 6 of common salt.

IV. Mix 27 parts of pulverized saltpetre, 28 of triturated chlorate of potassium, 15 of pulverized sulphur, 15 of pulverized sulphate of potassium, and

15 of powdered cupro-ammonium sulphate.

The dark-blue color will gain intensity by adding potassium sulphate to the mixture.

V. Seventeen hundred and fifty parts of chlorate of potassium, 500 of sulphur, 575 of carbonate of copper, and 375 of burned alum.

VI. Twenty-one parts of chlorate of potassium, 23 of copper precipitated with chlorate of potassium, 12 of sulphate of copper, 12 of calomel, 4 of milk sugar, and 3 of stearine.

Dark-blue Fire. Mix 60 parts of chlorate of potassium, 16 of sulphur, 12 of carbonate of copper, and 12 of alum.

Pale-blue Fire. I. Mix 61 parts of powdered chlorate of potassium, 16 of pulverized sulphur, and 25 of strongly heated and pulverized alum.

II. Mix 61 parts of powdered saltpetre, 17½ of pulverized sulphur, 20 of powdered anhydrous soda, and 1½ of pulverized charcoal.

Blue Fire with a Bluish-green Flame. Rub fine and mix 12 parts of nitrate of barium, 5 of chlorate of potassium, and 4 of sulphur.

Green Fire. I. Rub fine and mix 433 parts of purified sulphur, 2250 of nitrate of barium, 166 of chlorate of potassium, 66 of arsenic, and 100 of charcoal.

II. Fifty parts of chlorate of potassium, 50 of nitrate of barium, 5 of charcoal, and a sufficient quantity of linseed oil to knead the mass.

Green Fire according to Braunschweiger. Three parts of shellac, 9 of nitrate of barium, 1½ of chlorate of potassium.

Other Receipts for Green Fire. I. Sixteen parts of nitrate of barium, 4 of sulphur, and 16 of chlorate of potassium.

II. Forty-five parts of nitrate of barium, 10 of sulphur, 20 of chlorate of potassium, 2 of calomel, 1 of lampblack.

III. Mix very carefully 12 parts of nitrate of barium dry as dust, 4 of sulphur, and 6 of chlorate of potassium.

IV. Powder and mix 6 parts of nitrate of barium, 1 of sulphur, 2 of chlorate of potassium, and ½ of charcoal.

Pale-green Fire. I. Rub fine and mix 60 parts of chlorate of potassium, 16 of sulphur, and 24 of carbonate of barium.

II. Sixty parts of nitrate of barium, 14 of washed flowers of sulphur, and 40 of chlorate of potassium.

III. Thirty-eight parts of nitrate of barium, 10 of chlorate of potassium, and 8 of charcoal.

IV. Six parts of nitrate of barium, 1 of sulphur, 2 of chlorate of potassium, and ½ of charcoal.

Dark-green Fire. One hundred and twenty parts of nitrate of potassium, 60 of washed flowers of sulphur, 45 of chlorate of potassium, 37½ of anhydrous carbonate of sodium, 2 of pulverized charcoal, and 22.5 of stearine.

Yellow Fire. I. Mix carefully 48 parts of sodium nitrate, 16 of sulphur, 4 of sulphide of antimony, and 1 of charcoal.

II. Rub as fine as possible and mix 20 parts of sodium nitrate, 3 of sulphur, and 1 of sodium sulphide.

III. Two thousand parts of chlorate of potassium, 500 of purified sulphur, and 750 of sodium carbonate.

IV. Fifteen hundred and sixty-six parts of saltpetre, 625 of sodium carbonate, and 400 of gunpowder.

V. Six parts of chlorate of potassium, 6 of potassium nitrate, 5 of sodium oxalate, and 3 of shellac.

VI. Sixty-one parts of chlorate of

potassium, 16 of sulphur, and 23 of anhydrous soda.

VII. One hundred and twenty parts of potassium nitrate, 30 of flowers of sulphur, 45 of chlorate of potassium, 37½ of anhydrous sodium carbonate, 2 of charcoal powder, 22½ of stearine.

VIII. Sixty-one parts of saltpetre, 17½ of sulphur, 20 of soda, and 1½ of charcoal.

OTHER COLORED FIREWORKS.

White Stars. Mix 32 parts of pulverized saltpetre, 12 of pulverized sulphur, 8 of powdered sodium sulphide, and 1 of gunpowder.

Red Stars. Rub fine and mix 40 parts of nitrate of strontium, 10 of chlorate of potassium, 13 of sulphur, 2 of charcoal, 5 of sodium sulphide.

Green Stars. Thirty parts of chlorate of barium, 10 of flowers of sulphur, and 1 of mastic.

Blue Stars. Rub fine and mix 20 parts of chlorate of potassium, 11 of sulphur, 14 of cupric oxide, and 1 of mastic.

Bluish-green Stars. I. Rub fine and mix 24 parts of nitrate of barium, 56 of chlorate of potassium, 30 of sulphur, and 1 of mastic.

II. Twenty parts of nitrate of barium, 18 of chlorate of potassium, 10 of sulphur, 1 of mastic, and 3 of sodium sulphide.

Yellowish-green Stars. I. Rub fine and mix 60 parts of chloride of barium, 30 of nitrate of barium, 20 of sulphur, and 1 of mastic.

II. Twenty parts of chlorate of potassium, 5 of sulphur, 1 of mastic, and 1 of carbonate of barium.

Yellow Stars. Rub fine and mix 16 parts of sodium nitrate, 5 of sulphur, 2 of sodium sulphide, and 1 of charcoal.

White Candles. Powder and mix 4 parts of saltpetre, 1 of sulphur, and 1 of sodium sulphide.

Red Candles. Rub fine and mix 26 parts of nitrate of strontium, 15 of chlorate of potassium, 12 of flowers of sulphur, 2 of charcoal, 2 of sodium sulphide, and 1 of mastic.

Green Candles. Mix 20 parts of chlorate of barium, 30 of nitrate of barium, and 10 of sulphur.

Blue Candles. Rub fine and mix 18 parts of chlorate of potassium, 6 of saltpetre, 10 of sulphur, and 6 of cupric oxide.

Bluish-green Candles. Rub fine and mix 20 parts of chloride of barium, 30 to 42 of nitrate of barium, 40 of chlorate of potassium, 10 to 22 of sulphur and of sodium sulphide.

Yellow Candles. Rub fine and mix 80 parts of sodium nitrate, 7 of sulphur, 3 of sodium sulphide, and 2 of mastic.

Japanese Matches. One part of powdered charcoal, 1½ of sulphur, and 3¼ of saltpetre.

According to another receipt they consist of 5 parts of lampblack, 11 of sulphur, and 26 to 30 parts of gunpowder. The mixture is made into a paste with alcohol, formed into small dice, and dried. When dry one of the little squares is fixed into the cleft of a lavender stalk, lighted on a candle, and held stem downward. After the first blazing off, a ball of molten lava will form from which the curious and very beautiful corruscations will soon appear.

Prof. Böttger says about *Japanese matches:* The mixture consists either of 3 parts by weight of lampblack, 8 of flowers of sulphur, and 15 of saltpetre (dry as dust); or 2 parts by weight of finely sifted lime-wood charcoal, 4 of flowers of sulphur, and 7 of saltpetre (dry as dust). The mode of preparing the matches is as follows: Cut the finest commercial tissue paper into strips about 6¼ inches long, 1 inch wide on one end, and running into a point at the other. By rolling these small strips of paper tightly together, commencing at the pointed end, and filling the lower part with from 30 to 45 grains of one of the above mixtures, a close imitation of the genuine Japanese matches will be the result.

Fireworks for Use in Rooms, according to Perron. Mix 12 parts of saltpetre, 15 of flowers of sulphur, and 30 of gunpowder. Then dissolve 2 parts of camphor in 8 of spirit of wine, and 4 of gum Arabic in water. Knead the whole into a dough, and form small cornered pieces from it which are dried. When ignited they give a beautiful light.

Pharaoh's Serpents. This curious chemical toy is prepared as follows: Dissolve mercury, with the aid of heat, in dilute nitric acid, being careful that there shall always be an excess of mercury present. When the action of the acid has ceased, decant the solution, and pour into it a solution of sulpho-cyanide of potassium or ammonium, which may be procured at any druggist's. Use about equal quantities of the two solutions. A precipitate of sulpho-cyanide of mercury falls out, which should be filtered off, washed, and dried. Then take for every pound of this substance 1 ounce of gum tragacanth, which should be soaked in water. When the gum is completely softened it is transferred to a mortar, and the dried precipitate is gradually rubbed up with it into a homogeneous paste, with the addition of a little water. This mass is filled into moulds of conical or other shape, made of silvered paper, and dried. When these are ignited by the application of a match at the conical end they form an enormous volume of ash, which proceeds in great coils from the body of the mass, and which by its serpentine movements, as it is formed, has suggested the name. (W.)

Harmless Substitute for Pharaoh's Serpents. The above-named experiment, though curious and interesting, is not altogether free from danger, because poisonous mercurial fumes are evolved during the combustion of the mass. On this account several substitutes have been suggested. One of these, which is almost as good as the original, and is not poisonous, is prepared in the following manner:

Take

Bichromate of potassium	2 parts.
Saltpetre	1 part.
White sugar	3 parts.

Pulverize each of the ingredients separately, and then mix them thoroughly. Make small paper cones of the desired size, and press the mixture into them. When quite dry they are ready for use. They should be kept away from moisture and light. (W.)

BLASTING COMPOUNDS, BLASTING POWDER, DYNAMITE, GUN-COTTON, GUNPOWDER, NITRO-GLYCERINE, FULMINATES, ETC.

Among the blasting compounds nitro-glycerine and the explosive substances, dynamite, etc., derived from it, occupy the foremost place.

Nitro-glycerine is obtained in the following manner: Fuming nitric acid of 49° to 50° Beaumé is mixed with twice its weight of highly concentrated sulphuric acid in a vessel kept cool by being surrounded with cold water. Ordinary commercial glycerine, free from lime and lead, is evaporated to 30° or 31° Beaumé. When entirely cold, it should be of a syrupy consistency. 7¼ pounds of the cold acid mixture are brought into a glass flask or earthen vessel; this is placed in cold water, and 1 pound of glycerine is slowly poured into it; constant stirring being kept up during the addition of the glycerine. Great care must be observed to avoid any heating of the mixture, as the consequence of this would be an oxidation of the glycerine with development of carbonic acid. When the mixture is complete, it is allowed to stand quietly for 5 or 10 minutes, when it is poured into 5 or 6 times its volume of cold water, to which a rotary motion has previously been imparted. The nitro-glycerine subsides quickly as a heavy oil, which, by decantation, is brought into a vessel of greater height than width. It is now washed with water, until not a trace of acid reaction is indicated by blue litmus paper, when it is put in flasks ready for use. It is a yellow or brown oil, heavier than water, and practically insoluble in it, but soluble in alcohol and ether. When impure or acid, it decomposes spontaneously in a short time, with development of gas, and formation of oxalic and glyceric acids.

Mowbray's Process of Manufacturing Nitro-glycerine. This product is preeminent because of its stable character. It freezes at 45° F., is clear as water, and never of an orange color. When detonated it does not produce what is known as glycerine headache and is non-explosive when frozen. These excellent qualities are imparted to it by the care taken in its preparation. The nitrifying acid is made in a well-ventilated building, in which are placed five retorts each of 1½ pounds' capacity and charged with 10½ ounces of sodium nitrate and 13¼ ounces of sulphuric acid. Terra-cotta pipes conduct the vapors from each retort into a row of four earthenware receivers standing upon a trestle raised slightly above the floor. 165 pounds of sulphuric acid are poured into the first two receivers and 110 pounds into the third, while the fourth remains empty. The nitric acid vapors are condensed in the receivers, whereby the mixture of acids required for nitrating is at once obtained. When the distillation, which requires 24 hours, is finished, the acid mixture (about 660 pounds) is drawn off and emptied into a large trough of soapstone. To remove the hyponitric acid, as well as to obtain a homogeneous mixture, *Mowbray* passes a current of air into the trough through an iron pipe, which answers the purpose perfectly. This operation is of great importance, as the presence of hyponitric acid and nitrous acid probably causes the spontaneous decomposition and consequent explosion of this substance. The room in which the nitrating process is carried on is about 103 feet long and contains 116 jars of earthenware in 9 wooden troughs. 18¾ pounds of acid are poured into each of the jars and the troughs are filled with ice water, or with a mixture of ice and salt, to within ½ inch of the edge of the jars containing the acid. Upon a shelf above the troughs are placed glass vessels, one for each jar. Each contains 2¼ pounds of *pure* glycerine (not crude glycerine), which is conveyed drop by drop into the acid mixture by means of a siphon and rubber hose. Beneath the shelf upon which the glycerine vessels stand runs an iron pipe 2½ inches in diameter, through which passes a current of cold and dry air, which is introduced into the jars, while the acid and glycerine intermingle, through glass tubes 16½ inches long and ½ inch in diameter. 1½ hours are required for the glycerine to run off, and the greatest attention and care are necessary during this time. The three workmen overseeing the mixing process walk constantly up and down with a thermometer in hand, and should they find the temperature rising in one of the jars, or that red vapors are emitted, they stir the mixture with a glass rod. It happens sometimes that the glycerine runs too rapidly, when the flow must be diminished, and in case the engine should cease working must be entirely stopped and the mixture stirred.

When the conversion of glycerine into nitro-glycerine is completed, and no more red vapors escape, the jars are emptied into a vat containing cold water (42.8° F.). The quantity produced amounts at each operation to 495 pounds. In this vat the oil subsides to the bottom, being covered with water about 6 feet deep. It remains here for 15 minutes, when, after the water has been run off, it is drawn off into another vat resembling an old-fashioned churn, but much larger. Here it is washed 5 times—three times with pure water and twice with a solution of soda, a current of air being passed through it at the same time. The water from the washing apparatus is allowed to run into a vat, and from this through two barrels buried in the ground, whence it finds its way to the outside. If any of the oil should have been carried off with the wash-water, it is regained in one of the barrels. The nitro-glycerine is then transported in copper vessels to a magazine about 300 feet distant from the work-room and emptied into crocks each having a capacity of 66 pounds. These are placed on wooden shelves, each holding about 20 crocks, which are immersed in water of about 70° F., reaching to within 6 inches of the edge of the crocks. Here they remain for 72 hours, during which time the impurities that may be contained in the oil rise to the surface in the form of a scum, which is removed with a spoon. The nitro-glycerine is then chemically pure, transparent as water, and strongly refracts light. In this condition it is ready for packing. The tin cans used for this purpose are coated inside with paraffine, and have a capacity of 61½ pounds each. When they are to be filled they are placed in a shallow wooden vat; the oil is first poured into copper cans and then through a rubber funnel into the tin cans. To render any oil which may be spilled harmless the precaution is used to cover the bottom of the vat with a thick layer of plaster of Paris, which quickly absorbs the fluid. When the cans have been filled they are placed in a wooden vat filled with ice water, or ice and salt, until their contents are frozen, and 30 to 40 of them are stored away together in smaller magazines at a distance of about 325 feet from the factory. For transporting the nitro-glycerine the tin cans are packed in open wooden boxes, the bottom of which is covered with several inches of sponge. Around the cans themselves are fastened two gutta-percha tubes crossing each other on the bottom of the can. To thaw the nitro-glycerine each can is provided with a tube about 10 inches long and 1½ inches in diameter, passing through the centre from top to bottom, into which water of from 70 to 90° F. is poured. The cans are closed by a cork covered with a piece of bladder. Sleighs are used in winter for transporting the cans, and in summer wagons covered with a layer of ice and this with a blanket.

R. Böttger recommends the following process as free from risk for preparing small quantities of nitro-glycerine: A few grammes of anhydrous and entirely pure glycerine are poured into a test-glass kept cool by being surrounded with a freezing mixture, and containing 1 part by volume of concentrated sulphuric acid of 1.52 gravity, and 2 parts by volume of stronger sulphuric acid of 1.83 gravity. The mixture is poured as quickly as possible into a larger volume of water. In this the nitro-glycerine, resembling drops of oil, subsides to the bottom; it is then washed and rewashed, first with water, and finally with a weak solution of soda. It is freed from water by means of a few small pieces of chloride of calcium, when a product will be obtained of such purity that it may be kept without risk for an indefinite time and without suffering decomposition.

Dynamite possesses all the properties of nitro-glycerine for blasting purposes, and is less dangerous. Explosion is accomplished by means of a percussion cap in the same manner as with nitro-glycerine. The most common mode of making dynamite is by mixing 75 per cent. of nitro-glycerine with 25 per cent. of powdered sand.

Dynamite, according to *H. Champion* and *H. Pellet*, may be divided into, *a*, dynamite with an inert absorbent (infusorial earth, ashes, tripoli, etc.), and *b*, dynamite with an active absorbent. In the latter variety rosin, finely-powdered coal, or saltpetre are used as absorbents. To this class belong dualin, lithofracteur, etc.

To make the manufacture of dynamite less dangerous, *A. Sobrero* suggests to stir infusorial earth with water into a dough, form it into shapes of suitable size, dry them at 212° F., and finally dip them into nitro-glycerine. Dynamite with 75 per cent. of effective explosive can be prepared in this manner.

Cellulose Dynamite. Franzl has succeeded in producing a nitro-glycerine powder which, while it possesses all the properties of dynamite prepared with infusorial earth, has the advantage of being unaffected by water. He found that certain organic absorbents possessed the property of retaining absorbed nitro-glycerine, even when placed under water, and did not lose their explosive power. The nitrogenized absorbents—wood fibre and gun-cotton—were found to be too dangerous for manufacturing large quantities. But *Franzl* has now succeeded in preparing a wood fibre which absorbs from 70 to 75 per cent. of nitro-glycerine, which retains these proportions unchanged when in contact with water, and which retains also its explosive power after being pressed out and dried.

Norbin & Ohlsson's Patent Dynamite consists of a mixture of ammonium nitrate, with 8 to 10 per cent. of pulverized charcoal or coal, and 10 to 30 per cent. of nitro-glycerine. The compound, which, on account of the hygroscopic property of the ammonium nitrate, must be kept in metallic cases or glass vessels, is exploded by means of a percussion cap.

A. Nobel's Dynamite is a mixture of 69 parts of saltpetre, 7 of paraffine or naphthaline, 7 of coal dust, and 20 of nitro-glycerine. It is claimed that the addition of paraffine or naphthaline renders the mixture less hygroscopic.

Lithofracteur, as manufactured by *Krebs & Co.* of *Deutz*, is composed of 52 parts of nitro-glycerine, 30 of infusorial earth, 12 of coal, 4 of saltpetre, and 2 of sulphur.

Dittmar's Dualin consists of 50 parts of nitro-glycerine, 50 of nitrated sawdust, and 20 of saltpetre.

New Dynamite by Anthoine & Genaud. In this preparation unsized paper takes the place of silica. The paper is not only saturated with nitro-glycerine, but dipped in succession into solutions of saltpetre, potassium chlorate, and potassium picrate.

Carboäzotine. This explosive mixture, patented in France by *de Soulages* and *Cahuc*, is composed of 50 to 64 parts of saltpetre, 13 to 16 of sulphur, 14 to 16 of spent tan, or very fine sawdust, 9 to 18 of lampblack, and 4 to 5 of ferrous sulphate. The mixture is heated with a suitable quantity of water to 230° to 248° F., then allowed to cool, and the solid mass dried and shaped into bricks.

Brise-rocs, an explosive agent patented by *Robaudi*, consists of 40 parts of saltpetre, 20 of soda saltpetre, 15 of sulphur, 1 of rock salt, and 15 of woody substance, spent tan, sawdust, etc.

Pudrolith. Poch's blasting powder, known under this name, consists of 3 parts by weight of spent tan, 5 of sawdust, 3 of soda saltpetre, 3 of barium nitrate, 6 of wood charcoal, 12 of sulphur, and 68 of saltpetre. The barium and sodium salts are dissolved in hot water, the tan and sawdust stirred into the solution, and the mixture is evaporated to dryness. The other ingredients, previously pulverized, are intimately mixed with the powdered residue in a revolving cylinder.

Pyrolith. This blasting powder, patented by *Wattlen*, and used for blasting hard rocks, such as granite, etc., consists of 12.5 parts by weight of sawdust, 67.5 of saltpetre, and 20 of flowers of sulphur.

For blasting softer rocks, such as limestone, coal, etc., *Wattlen* recommends the following composition: 11 parts by weight of sawdust, 50.5 of saltpetre, 16 of soda saltpetre, 1.5 of powdered charcoal, and 20 of flowers of sulphur.

Trets' Blasting Powder, patented in *England*, consists of 52.5 per cent. of Chili soda saltpetre, 20 per cent. of sulphur, and 27.5 per cent. of spent tan.

Frozen Dynamite. Dynamite, when frozen solid, is comparatively valueless, as in thawing for use it becomes injured and sometimes ignites; but by granulating it, as freezing takes place, and keeping it in this condition, it may be transported, handled, or poured and rammed into bore holes with entire safety and convenience. Freezing the dynamite in grains may be readily accomplished by passing it through a coarse sieve after it is manufactured, but just before it congeals, and allowing it to fall loosely and lie undisturbed during its exposure to a freezing temperature. The particles will slightly adhere, but may be readily separated by stirring. Dynamite so frozen will readily explode by the ordinary means, but the cap should have about three times the usual quantity of fulminate.

Augendre's White Powder. This powder may be advantageously used for blasting very hard rock, although it is somewhat expensive. Considerable care and caution are required in ramming it into the drill holes, and for this reason the work should be only intrusted to experienced workmen. By the following process *Augendre's* gunpowder can be produced as a very homogeneous mixture and of great explosive energy. The three ingredients of white gunpowder, potassium ferrocyanide, sugar, and potassium chlorate, are pulverized, each by itself, in a mortar, and then thoroughly dried. Each of the ingredients, when dry, is again pulverized as finely as possible, and passed through a fine hair sieve. The respective quantities of the ingredients are then weighed off, poured upon a sheet of paper, and intimately mixed with the fingers or with a feather. The powder is then placed in a capacious porcelain mortar, moistened with absolute alcohol, and an intimate mixture is produced by continued rubbing with a pestle, the process being entirely free from danger if done in this manner. The powder, which is now in the form of a stiff dough, is spread upon a smooth board and dried in a warm room. The alcohol evaporates quickly, when the thin, dry cakes of powder are crushed between two smooth boards, and the powder passed through a fine sieve. In this manner it is obtained in the form of very fine, intimately mixed dust, possessing excellent explosive properties.

Hafenegger's Gun and Blasting Powder, several varieties of which have been patented in England, resembles *Augendre's* white powder. Their composition is as follows:

I. Nine parts of potassium chlorate, ¼ of sulphur, and ¼ of wood charcoal.

II. Two parts of potassium chlorate, 1 of refined sugar, and 1 of potassium ferrocyanide.

III. Four parts of potassium chlorate, 1 of sulphur or sugar, ¼ of wood charcoal, and 1 of potassium ferrocyanide.

IV. Four parts of potassium chlorate, 4 of sugar, ¼ of wood charcoal, and ¼ of sulphur.

V. One part of potassium chlorate and 1 of sugar.

VI. Eleven parts of potassium chlorate, ¼ of sulphur, and ¼ of wood charcoal.

Dr. Borlinetto's Gunpowder. Mix very intimately 10 parts of Chili saltpetre, 10 of picric acid, and 8½ of potassium bichromate.

Sharp & Smith's Patent Gunpowder consists of 2 parts of saltpetre, 2 of potassium chlorate, 1 of potassium ferrocyanide, 1 of potassium tartrate, and 2 of sulphur.

Spence's Powder for Cannon of Large Calibre. Two parts by weight of finely-pulverized charcoal are boiled with 38 parts by weight of water. The boiling is interrupted after a short time, and, with constant stirring, 20 parts by weight of potassium chlorate, 2 of pulverized coal, and 4 of sodium bicarbonate are added to the mixture of charcoal and water. The mass is again brought to the boiling point, 7 parts by weight of fine sawdust are added, and the boiling continued until the woody mass has formed a magma with the water. When this is done the mass is evaporated in open pans until it is of a consistency to be granulated in the usual manner in the powder-mill.

Non-explosive Powder. When this powder is ignited it does not explode, but burns slowly with a hissing noise. It loosens and raises stones without blasting them. It is cheaper than the ordinary powder, of quite a coarse grain, and contains 3 parts of potassium nitrate to 1 of sodium nitrate. The powder is mixed in the following proportions: 56.22 to 56.23 per cent. of potassium nitrate, 18.33 to 18.39 per cent. of sodium nitrate, 9.68 per cent. of sulphur, and 14.14 to 15.01 per cent. of charcoal.

Green's Blasting Powder consists

principally of barium nitrate, contains but little saltpetre and no sulphur. There is less danger in manufacturing it than gunpowder, but it is not fit for firearms. It possesses the great advantage of not emitting thick smoke or choking gases, and therefore does not interrupt the work in mines; and further, that it takes up less room than gunpowder and is much cheaper. Its effect as compared with gunpowder is as 18 to 11.

Giant Dynamite is a mixture of 18 to 28 parts by weight of pyroxyline, 55 to 44 of nitro-glycerine, 5 to 10 of pyro-paper, 20 to 16 of nitro-starch, 1 to 1 of nitromannite, and 1 to 2 of water-glass The materials, which should be free from acid, are carefully mixed and brought under a cartridge press, in the stamp of which is fastened a needle which makes a hole in the cartridge for the reception of the fuse. The cartridge thus prepared is hermetically closed with collodion, and packed in the same manner as lithofracteur. Shortly before the cartridge is to be used the coating of collodion is broken on those places where the holes are for the reception of the fuse. This consists of soft gun-cotton impregnated with potassium chlorate and plumbic ferrocyanide, and is prevented from dropping through by a knot on one end. It is drawn through the holes and a *Bickford's* fuse fastened to the other end.

Blasting Compound from Potato-Starch. The process is similar to that of manufacturing nitro-glycerine. The potato-starch is shaken with concentrated nitric acid until it is dissolved, and then, with vigorous stirring, poured into sulphuric acid, whereby the preparation is separated in a finely-divided condition. All traces of acid are then removed by washing and rewashing, and treating the preparation with sodium carbonate. The explosive starch flour, when dry, forms a tender white powder. When touched with a glowing piece of wood it is quickly consumed with a yellow flame without leaving a residue. A great advantage of the explosive starch flour is that it explodes only after having been repeatedly struck with a hammer upon an anvil. Its ignition temperature is between 356° and 374° F. In external appearance this explosive agent does not differ from ordinary starch flour. It remains entirely unchanged when boiled in water, but loses the property of being colored blue by iodine. If examined with the microscope the well-known starch globules cannot be detected.

A New Blasting Powder, patented in Germany by *Th. Martinsen*, consists of:

	PARTS.		
	I.	II.	III.
Saltpetre	70	64	56
Sulphur	12	12	22
Lampblack	5	3	3
Sawdust or tan	13	21	29
Ferrous sulphate	2	3	5

The ferrous sulphate is completely dissolved in a little water, and the other components are mixed with it at 248° to 266° F. The mixture is cooled off by constantly stirring it and then dried. This powder can be stored, transported, and used without danger, and develops no smoke in the mine. The first mixture is intended for dense rocks, the second for anthracite, and the third for bituminous coal.

To protect blasting agents containing nitro-glycerine and ammonium nitrate from moisture, and to prevent the exudation of the nitro-glycerine, Nobel adds paraffine to them. He recommends the following proportions: 69 per cent. of sodium nitrate, 7 per cent. of paraffine, and 4 per cent. of charcoal.

These ingredients are carefully mixed, and 20 per cent. of nitro-glycerine is added to the mixture. Or, 75 per cent. of ammonium nitrate, 3 per cent. of charcoal, 4 per cent. of paraffine, and 18 per cent. of nitro-glycerine.

Giant Powder. Forty parts of nitroglycerine are mixed with 60 parts of a dry mixture, consisting of 40 parts of sodium nitrate, 6 of rosin, 6 of sulphur, and 8 of infusorial earth or other analogous absorbent substance. This forms a powerful blasting compound, which will not ignite from contact with flame nor from a blow, but may be readily exploded by the shock given by discharging a cap containing fulminate.

Faure & French's Blasting Compound is a mixture of 1 part of charcoal, 16 of barium nitrate, and 1 of nitro-cellulose stirred into a dough with some water and then formed into disks and dried.

Gun-Cotton. Cotton-wool is immersed in a boiling dilute solution of potassium carbonate, then washed with water and well dried. It is now steeped for a few minutes in a cold mixture of 1 part of concentrated nitric acid and 3 of oil of vitriol, then squeezed, and again placed in a fresh acid mixture and left there for 48 hours. It is then again well squeezed and washed for a long time with running water, and finally steeped in a solution of potassium carbonate.

Gun-cotton thus manufactured will keep without change indefinitely, and may be kept under water for safety's sake, and possesses, after drying, all its original properties.

It is insoluble in water, alcohol, and ether. It takes fire at 300° F., burning away rapidly but without explosion; but when ignited in a confined space, or by percussion, it decomposes with a violent detonation, the energy of which equals that of five times its weight of gunpowder.

New Blasting Compounds.

1. *Peralite* is a coarse-grained powder consisting of 64 per cent. of saltpetre, 30 per cent. of charcoal, and 6 per cent. of sulphide of antimony.

2. *Juline* contains 65 to 75 per cent. of saltpetre, 10 per cent. of sulphur, 10 to 15 per cent. of lignite, 3 to 8 per cent. of sodium picrate, and 2 per cent. of potassium chlorate.

New Blasting Compound from a Combination of Honey and Glycerine. The following proportions by weight are used:

No. I. Fifty parts of combination of honey and glycerine, 12 of potassium chlorate, 16 of potassium nitrate, 17 of prepared sawdust, and 5 of prepared chalk.

No. II. Thirty-eight parts of combination of honey and glycerine, 19 of potassium chlorate, 24 of potassium nitrate, 10 of prepared sawdust, and 9 of prepared chalk.

The combination of honey and glycerine is prepared as follows: Mix 1 part of nitric acid of 1.50 specific gravity and 2 parts of sulphuric acid of 1.84 specific gravity, and let the mixture cool off to 62° F. Eight parts of this mixture are placed in a wooden vessel lined with lead, and to this is added, with slow and constant stirring, 1 part of a mixture of equal parts of honey and glycerine, keeping the temperature of the compound between 59° and 68° F. After stirring for about 5 minutes the combination of honey and glycerine settles on the bottom of the vessel. It is then separated from the supernatant acid and washed first with water and next with a solution of soda to remove the last traces of acid. It is now ready for mixing with the other ingredients, which must have been previously pulverized and intimately mixed. The sawdust flour is prepared by passing ordinary sawdust through a fine sieve and boiling it in a solution of soda until all resinous and coloring substances have been extracted, when it is washed in cold water and dried.

Preparation of Blasting Compounds by directly Nitrating Crude Tar Oils. The crude tar oils are gradually, compounded by constant stirring with nitric acid of a high grade. The clear oil standing over the precipitate is poured off into another vessel, nitric acid added to the residue, and the process repeated.

The nitrogenized substances obtained in this manner are washed, dried, and mixed with substances yielding oxygen. The nitrates of alkalies, potassium chlorate, and the strongest nitric acid (1.5 specific gravity) are principally used for the purpose.

Gelatinous Nitro-glycerine. Cotton carefully cleansed and comminuted is boiled in a closed boiler with 5 parts by weight of dextrine and some acetate of ammonium; the resulting jelly, of which as much as 7 per cent. may be dissolved in nitro-glycerine, forms with it a mass from which no nitro-glycerine can escape.

To prepare the blasting compound "*Forcite*" 76 parts of the above gelatinous nitro-glycerine are mixed with 15 parts of saltpetre and 9 of sawdust.

Cartridge Shells of Easily Combustible Substances. The material consists of very loosely woven cotton or silk tissue, which is impregnated with nitroglycerine, or with a mixture of sulphur and saltpetre. When the tissue is dry, collodion, to which a small quantity of castor oil has been added, is poured over it and it is then smoothed between rollers.

Fulminate of Mercury is used for filling percussion caps. It is prepared on a large scale by dissolving 1 part of mercury in 12 of pure nitric acid of 1.36 specific gravity, and adding 12 of spirit of wine, when a violent reaction takes place, which is kept in check by adding gradually more alcohol. First, the liquid becomes black by the separation of metallic mercury, which, however, soon disappears. When the liquid becomes cool the fulminate of mercury separates as a crystalline powder. It is nearly insoluble in cold water: from a boiling solution it is obtained in white prismatic crystals. When kindled in the open air it burns away like gunpowder, but by percussion it is decomposed with a violent detonation. The explosion of the fulminate is so violent and rapid that it is necessary to moderate it for percussion caps. For this purpose it is mixed with potassium nitrate or chlorate. For gun caps potassium chlorate is generally mixed with the fulminate, and powdered glass is sometimes added to increase the sensibility of the mixture to explosion by percussion. After a little of the composition has been introduced into the cap, it is made to adhere by a drop of solution of shellac in spirit of wine, which renders it also water-proof.

Fulminate of Silver. Ten grains of pure silver are dissolved, at a gentle heat, in 70 drops of concentrated nitric acid of 1.42 specific gravity and 50 drops of water. As soon as the silver is dissolved the heat is removed and 2,000 drops of alcohol are added. If the action does not commence after a short time, a very gentle heat may be applied until effervescence begins, when the fulminate of silver will be deposited in minute needles, and may be further treated as in the case of fulminate of mercury. When dry the fulminate of silver must be handled with the greatest caution, since it is exploded far more easily than the fulminate of mercury. It should be kept in small quantities, wrapped up separately in paper, and placed in a pasteboard box. The violence of its explosion renders it useless for percussion caps, but it is employed in detonating crackers.

Fulminating Platinum is obtained by dissolving binoxide of platinum in diluted sulphuric acid and mixing the solution with an excess of ammonia, when a black precipitate will result which detonates violently at about 400° F.

Fulminating Gold is obtained as a buff-colored precipitate when ammonia is added to a solution of terchloride of gold. It explodes violently when gently heated.

EXPLOSIVE AGENTS.

Blasting Cartridges. Dissolve 73 parts of saltpetre and 1 of magnesium sulphate in ⅓ of their weight of boiling water, and compound with 8 parts of ground wood charcoal, 8 of bran, and 10 of sulphur, previously mixed dry. Stir the mass thoroughly, and heat for 2 hours at a temperature of 284° F., and then dry in a drying apparatus for 5 hours at a temperature of 122° F. The dried mass is pressed into cylinders, four of which are generally formed into a cartridge in a paper shell.

Blasting Paper. Coat unsized paper with a hot mixture of 11 drachms of ferrocyanide of potassium dissolved in 3½ pints of water, 11 ounces of basswood charcoal, 1¼ ounces of refined saltpetre, 2½ ounces of potassium chlorate, and 6½ drachms of wheat starch, stirred to a paste with 1⅓ ounces of water; dry and smooth. For use roll strips of the prepared paper into cartridges.

Explosive Combination. An explosive combination consists, according to a French patent, of 80 parts of powdered potassium chlorate, 20 parts of ordinary coal tar, and a porous, absorbent substance, such as pulverized wood-charcoal or silicious earth. Potassium permanganate can be substituted for a portion of the chlorate.

Explosive Substance. This, according to an English patent, consists of 9 parts of potassium chlorate, 2 of carbohydrate (sugar), 1 of flour, and 1 of ferrocyanide of potassium.

Explosive and Pyrotechnic Substances. Ferrocyanide of potassium, saltpetre, and chlorate of potassium are dissolved and mixed with pulverized charcoal. The water is then evaporated, and the substances are combined by the admixture of paraffine or resins. The paraffine is used either melted or dissolved in benzine. The mass is made into any desired shape, and can also be used for coating paper.

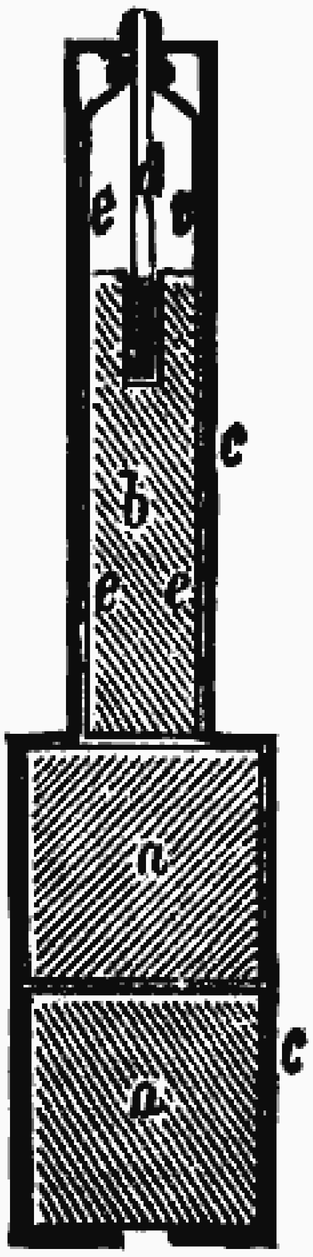

Fig. 60.

Method of Blasting under Water with Compressed Gun-cotton. In the accompanying illustration, Fig. 60, *aa* represent layers of gun-cotton, *b* the cartridge of compressed gun-cotton, and *d* the quick match with the cap. The cartridge is enclosed in the rubber tube *e*, which on the top is fastened watertight around the quick-match, so that when the cartridge is placed under water the latter can penetrate the guncotton only from below. The entire charge is enclosed in the tin case *c*, which is open on top and bottom for the passage of water. The cartridge remains explosible until all the guncotton is soaked through by the water entering from below, which with a cartridge about 1 inch in diameter and 4¾ inches long will be the case in exactly 22 hours, which makes the unexpected explosion of a charge missing fire impossible after that time.

New Blasting Powder. Saltpetre, potassium chlorate, and finely-pulverized coal-tar pitch are converted with benzine into a plastic paste, which is made into flat cakes and freed from the benzine by evaporation, and then worked in the same manner as ordinary powder. The grains, which, like those of the ordinary article, are irregular in form, can be made of any desired size. The density, which is 0.9 or somewhat more, corresponds with that of ordinary gunpowder. This new powder possesses considerable hardness, does not lose color, even when wet, and without undergoing a change stands a higher degree of heat than that of melting tin. It is not inflammable by single sparks of short duration. Ignited free, it burns quickly with a white flame; in a closed space it burns, however, very energetically with little smoke and leaving a very small residue. A gun is not in the least affected by its combustion products. The advantages of this powder are: 1. Facility and quickness of manufacture. 2. Safety in its preparation. 3. Absence of all hygroscopic properties (4 ounces placed upon a very sensitive scale in an open window for 4 days of misty weather did not increase in weight). 4. Superior force, 2½ times that of ordinary powder. 5. Very small residue. 6. Scarcely perceptible smoke.

New Method of Preparing Giant Powder. Two mixtures are prepared:

a. 36.06 parts of potassium or sodium bisulphate, 28.60 of potassium nitrate, and 9.20 of glycerine.

b. 50 to 55 parts of some chlorate, and 50 to 45 parts of a substance rich in carbon.

On igniting a mixture of the two, it is claimed mixture *b* evolves sufficient heat to effect the nitrification of the glycerine and explosion of the nitroglycerine. The material rich in carbon is saturated with concentrated solutions of the bisulphate, nitrate, and chlorate, and dried. The mass is then mixed with the glycerine and made into cartridges.

Preparation of Hyponitric Acid and its Use for Explosive and Illuminating Substances. The following process has been patented in France and Germany: Nitrate of lead is heated in the retort *A* (Fig. 61). The developed gases are first conducted through sulphuric acid, which retains the moisture, and then into the condensers *C* of enamelled cast-iron, which rest in the cooling vessel *E*, whose cooling fluid is kept at zero by the ice machine *G*. While the oxygen escapes for further use through *D*, the hyponitric acid collects in the reservoirs *H* and *J*, the first of which is provided with a test-cock for the examination of the acid. The reservoir *I* contains sulphuric acid. From *J* the hyponitric acid is brought by the pump *O* into the vessel *L*, and from there is drawn into tin cans. The oxide of lead in the retorts is reconverted into nitrate by nitric acid.

A mixture of carbon di-sulphide and hyponitric acid is a powerful explosive, which is exploded by fulminate of mercury or gunpowder. It does not explode by a shock alone, nor by heating to 398° F. A mixture of equal parts of hyponitric acid and carbon di-sulphide gives the most powerful explosion.

The mixture burns in the open air with a brilliant white light, which is powerfully actinic.

MATCHES.

Swedish Matches are made in Sweden almost exclusively of white poplar wood, it being the cheapest. Blocks of the length of the match are cut by machinery from the round logs and splintered, the splints kiln-dried and coated with paraffine. The end to be covered with the inflammable compound is dipped in a solution of paraffine in benzine, when they are again dried. They are then dipped into the inflammable compound, which should be of such a consistency that only small drops remain adhering to the stick. The following mixtures are used :

	PARTS.			
	I.	II.	III.	IV.
Chlorate of potassium	2000	2000	2000	4000
Plumbic dioxide . .	1150	2150		
Minium	2500	2500	2000	4000
Antimony trisulphide	1250	1250	1300	3000
Chromate of potassium	1318		750	1500
Gum-Arabic	670	670	670	670
Paraffine	250	250		

In Nos. I. and II. the paraffine is first rubbed up with the antimony and then incorporated with the compound. The compound ignites easily and transmits the flame quickly to the wood. Matches with compound No. II. ignite well and burn quietly. Matches with No. III. ignite easily on the striking surface and quickly transmit the flame to the wood. Compound No. IV. furnishes matches exactly like those of the *Jönköping* product; they ignite easily on the striking surface, transmit the flame quickly to the wood, burn quietly and without noise.

Striking Surface of Swedish Matches consists of a compound prepared by

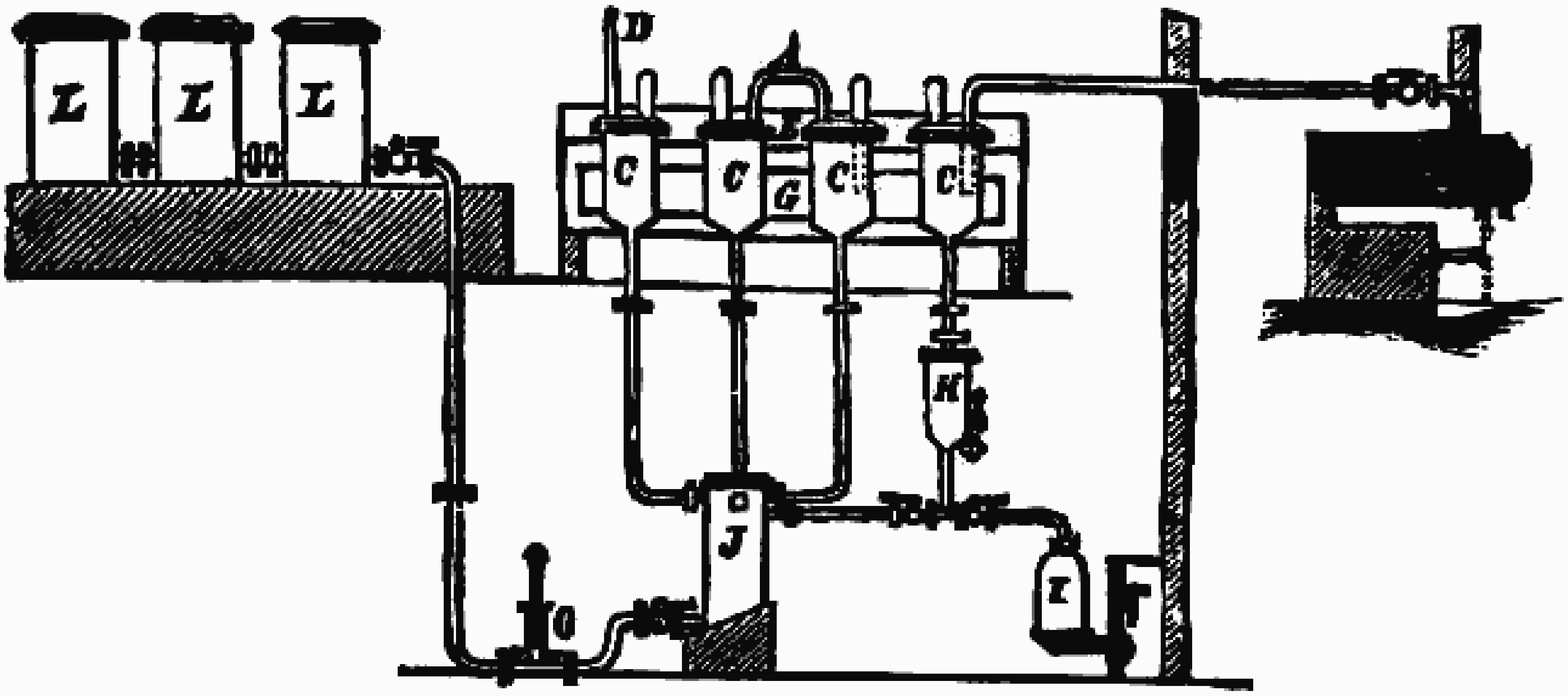

Fig. 61.

mixing 9 parts of amorphous phosphorus, 7 of iron pyrites pulverized and sifted, 3 of pulverized glass, and 1 of glue or gum with the requisite quantity of water.

Matches without Sulphur, which can be ignited by friction on any surface and do not absorb moisture from the air, are prepared by dipping the matches into a hot solution of any kind of fat, and using the following inflammable compound: Seven parts of phosphorus, 7 of gum-Arabic, 40 of lead nitrate, 5 of pulverized glass, and 10 of water.

Inflammable Compounds. H. Schwarz recommends the following mixtures as giving excellent results: I. One part of pulverized sulphur is melted in warm water with 4 of yellow phosphorus. Most of the water is then poured off and the fluid mixture rubbed intimately with 4 parts of dextrine gum. Now compound 45 parts of minium with 1½ equivalent of nitric acid, dry the mixture, pulverize it, and add it gradually to the phosphorus mixture. The matches are saturated with solution of pine rosin in alcohol, and dried at a moderate heat.

II. Mix 1 part of phosphorus, 5 of chalk, 2.8 of anhydrous gypsum, 6 of pulverized glass, and 6 of some agglutinant and coloring matter. This compound requires a rough striking surface, ignites with a slight report, and does not absorb moisture.

Inflammable Compound without Phosphorus. Thirty-six parts of plumbic dioxide, 15 of chlorate of potassium, 9 of manganese dioxide, 8 of flowers of sulphur, 6 each of infusorial earth, pulverized glass or sand and amorphous phosphorus, and 8 of glue.

The compound ignites by friction on any surface.

Parlor Matches. The sticks are first thoroughly dried, then soaked with stearic acid, and finally dipped into an inflammable compound prepared from 3 parts of phosphorus, ½ of gum tragacanth, 3 of water, 2 of fine sand, and 2 of red lead. To perfume the matches they are dipped, after the compound is dry, into a solution of aromatic gum, made of 4 parts of benzoin in 10 of spirit of wine of 40° B.

Colored Parlor Matches. The inflammable compound on the end of the matches may be coated with different colored lacquers to give a variegated appearance when placed in boxes.

The lacquers are prepared in the following manner: Eight parts of pulverized rosin are dissolved in a hot mixture of 200 parts of alcohol and 4 parts of glycerine, and 40 parts of solution of shellac added to the hot solution. The whole is then thoroughly agitated and, while yet warm, compounded with the necessary quantity of coloring matter, and finally allowed to cool.

The green iridescent bronze color, which is in great demand, requires for the above solution of lacquer 80 parts of crystallized fuchsine, or 28 parts of methyl-violet. To produce *violet* an addition of only ½ part of methyl-violet is required; for *blue* ¾ part of aniline blue soluble in water; for *orange* 4 parts of aniline orange; for *blue-green* ½ part of methyl-green. For *yellow-green* 2 parts of blue-green are mixed with 1 of orange; and for *red* 32 parts of coralline with an addition of 2 parts of caustic soda-lye, dissolved in the above lacquer.

Anti-phosphorus Matches. The paste

for the friction surface consists of minium, sand, and amorphous phosphorus rubbed up with a solution of gum-Arabic and applied with a brush; or of 10 parts of amorphous phosphorus, 8 of pyrolusite or antimony trisulphide, and 3 to 6 of glue dissolved in water. To prepare the matches the ends are first dipped into melted sulphur, stearic acid, or wax, and then into a compound of 6 parts of chlorate of potassium and 2 to 3 of trisulphide of antimony mixed with a solution of 1 part of glue in water. It must be remarked here that the mixture of bichromate of potassium and antimony is exceedingly dangerous, as it is easily ignited by a shock or friction.

Matches Inextinguishable by the Wind. Sheets of paper, thin pasteboard, or wood are saturated with a solution of saltpetre in water to which has been added some substance emitting an agreeable odor while burning. When the sheets are dry, a thin layer of a phosphorus compound, as is used in the manufacture of friction matches, and to which some incombustible substance, as pulverized glass, fine sand, etc., has been added, is placed between two of them, leaving a part of one end free for handling. When dry the 2 sheets are pasted together, and this is cut up into strips of suitable shape. These strips are then coated with a varnish to protect them from moisture and to prevent their ignition by friction during transportation, etc.

Matches without Phosphorus. Prepare a paste of 10 parts of dextrine, 75 of pulverized chlorate of potassium, 35 of pulverized plumbic dioxide, and a like quantity of pulverized pyrites with the necessary quantity of water, and dip the end of the splints into the compound.

Matches without Phosphorus, of an excellent quality, and in the manufacture of which there is not the slightest danger, are obtained from the following mixture: 53.8 parts of chlorate of potassium, 10 of gum-Arabic, 3 of gum tragacanth, 6 of pyrolusite, 6 of ferric oxide, 12 of pulverized glass, 5 of bichromate of potassium, 3 of sulphur, 1.2 of chalk, and sufficient water.

Paraffine or sulphur is used for transmitting the flame to the wood. The matches can only be ignited by being struck on a surface composed of the following mixture: Five parts of antimony trisulphide, 3 of amorphous phosphorus, 14 of pyrolusite, and 4 of glue.

Amorces d'Allumettes are matches prepared from 20 parts of phosphorus, 5.5 of gun-cotton, 5 of pulverized wood charcoal, 5 of iron filings, 51.5 of sulphur, and 10 of gum.

Nickle's Process of Preparing an Amorphous Phosphorus from the Ordinary Article. The conversion of ordinary into amorphous phosphorus is accomplished by heating ordinary phosphorus from 446° to 482° F. in a closed iron boiler. After 3 or 4 weeks the phosphorus is found to be converted into a red, brittle mass which is ground by millstones under water, and separated from the ordinary phosphorus either by bisulphide of carbon or caustic soda, in which the latter is soluble. The temperature requires careful regulation, for if it is allowed to rise to 500° F. the amorphous phosphorus quickly resumes the ordinary condition, evolving the heat which it had absorbed during its conversion, and thus converting much of the phosphorus into vapor. This reconversion may be shown by heating a little amorphous phosphorus in a test-tube, when drops of ordinary phosphorus condense on the cool part of the tube. Ordinary phosphorus is very poisonous, while amorphous phosphorus appears to be harmless. The vapor of phosphorus produces a very injurious effect upon the persons engaged in the manufacture of matches, resulting in the decay of the lower jaw. This evil may be greatly mitigated by good ventilation or by diffusing turpentine vapor through the air of the work-room, or may be entirely obviated by substituting amorphous phosphorus for the ordinary variety.

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Henley's Twentieth Century Formulas 1907

Pyrotechnics

FIREWORKS.

The chief chemical process is, of course, oxidation. Oxidation may be produced by the atmosphere, but in many cases this is not enough, and then the pyrotechnist must employ his knowledge of chemistry in selecting oxidizing agents.

The chief of these oxidizing agents are chlorates and nitrates, the effect of which is to promote the continuance of combustion when it is once started. They are specially useful, owing to their solid non-hygroscopic nature. Then ingredients are needed to prevent the too speedy action of the oxidizing agents, to regulate the process of combustion, such as calomel, sand, and sulphate of potash. Thirdly, there are the active ingredients that produce the desired effect, prominent among which are substances that in contact with flame impart some special color to it. Brilliancy and brightness are imparted by steel, zinc, and copper filings. Other substances employed are lampblack with gunpowder, and, for theatre purposes, lycopodium.

Fireworks may be classified under four heads, viz.:

1. Single fireworks.
2. Terrestrial fireworks, which are placed upon the ground and the fire issues direct from the surface.
3. Atmospheric fireworks, which begin their display in the air.
4. Aquatic fireworks, in which oxidation is so intense that they produce a flame under water.

Rockets.—First and foremost among atmospheric fireworks are rockets, made in different sizes, each requiring a slightly different percentage composition. A good formula is

Sulphur............	1 part
Carbon, wood.......	2 parts
Niter..............	4 parts
Meal powder........	1 part

Meal powder is a fine black or brown dust, which acts as a diluent.

Roman Candles.—Roman candles are somewhat after the same principle. An average formula is:

Sulphur............	4 parts
Carbon.............	3 parts
Niter..............	8 parts

CHILDREN'S SAFE FIREWORKS (SPARKLERS):

Coat 12 inch lengths of No. 18 Iron Wire with a compound consisting of:

Powdered sulphur ...	1	ounce
Potassium nitrate ...	5	ounces
Powdered charcoal ..	1½	ounces
Iron filings	2	ounces
Aluminum powder ...	¼	ounce

mixed in shellac to a thick creamy consistency. Dip the wires in the mixture and then insert the base end of wires in holes drilled into a board, until the mixture dries. Repeat this process until each wire is covered with a thick coat.

COLORED FIRES.

The compounds should be ignited in a small pill box resting on a plate. All the ingredients must be dried and powdered separately, and then lightly mixed on a sheet of paper. Always bear in mind that sulphur and chlorate of potassium explode violently if rubbed together.

Smokeless Vari-Colored Fire.—First take barytes or strontium, and bring to a glowing heat in a suitable dish, remove from the fire, and add the shellac. The latter (unpowdered) will melt at once, and can then be intimately mixed with the barytes or strontium by means of a spatula. After cooling, pulverize. One may also add about 2½ per cent of powdered magnesium to increase the effect. Take for instance 4 parts of barytes or strontium and 1 part of shellac.

The following salts, if finely powdered and burned in an iron ladle with a little spirits, will communicate to the flame their peculiar colors.

Potassium nitrate or sodium chlorate, yellow.
Potassium chlorate, violet.
Calcium chloride, orange.
Strontium nitrate, red.
Barium nitrate, apple green.
Copper nitrate, emerald green.
Borax, green.
Lithium chloride, purple.

The colored fires are used largely in the production of various theatrical effects.

Blue Fire.—

I.—Ter-sulphuret of antimony	**1 part**
Sulphur	**2 parts**
Nitrate of potassium	**6 parts**
II.—Sulphur	15 parts
Potassium sulphate	15 parts
Ammonio-cupric sulphate	15 parts
Potassium nitrate	**27 parts**
Potassium chlorate	**28 parts**
III.—Chlorate of potash	8 parts
Calomel	4 parts
Copper sulphate	5 parts
Shellac	3 parts
IV.—Ore pigment	2 parts
Charcoal	3 parts
Potassium chloride	5 parts
Sulphur	13 parts
Potassium nitrate	77 parts
V.—Potassium chlorate	10 parts
Copper chlorate	20 parts
Alcohol	20 parts
Water	100 parts
VI.—Copper chlorate	**100 part**
Copper nitrate	**50 parts**
Barium chlorate	**25 parts**
Potassium chlorate	**100 parts**
Alcohol	**500 parts**
Water	**1,000 parts**

Green.—

I.—Barium chlorate	**20 parts**
Alcohol	**20 parts**
Water	**100 parts**
II.—Barium nitrate	**10 parts**
Potassium chlorate	**10 parts**
Alcohol	**20 parts**
Water	**100 parts**
III.—Shellac	**5 parts**
Barium nitrate	**1½ parts**

Pound after cooling, and add

Barium chlorate, 2 to 5 per cent.

Red.—

I.—Shellac	**5 parts**
Strontium nitrate	**1 to 1.2 parts**

Preparation as in green fire. In damp weather add 2 to 4 per cent of potassium chlorate to the red flame; the latter causes a little more smoke.

II.—Strontium nitrate	**20 parts**
Potassium chlorate	**10 parts**
Alcohol	**20 parts**
Water	**100 parts**

Yellow.—

I.—Sulphur	**16 parts**
Dried carbonate of soda	**23 parts**
Chlorate of potassium	**61 parts**
II.—Sodium chlorate	**20 parts**
Potassium oxalate	**10 parts**
Alcohol	**20 parts**
Water	**100 parts**

Violet.—

I.—Strontium chlorate	**15 parts**
Copper chlorate	**15 parts**
Potassium chlorate	**15 parts**
Alcohol	**50 parts**
Water	**100 parts**
II.—Potassium chlorate	**20 parts**
Strontium chlorate	**20 parts**
Copper chlorate	**10 parts**
Alcohol	**50 parts**
Water	**100 parts**

Lilac.—

Potassium chlorate	20 parts
Copper chlorate...	10 parts
Strontium chloride.	10 parts
Alcohol	50 parts
Water...........	100 parts

Mauve.—

Chlorate of potash .	28 parts
Calomel..........	12 parts
Shellac...........	4 parts
Strontium nitrate . .	4 parts
Cupric sulphate . . .	2 parts
Fat..............	1 part

Purple.—

Copper sulphide. . .	8 parts
Calomel..........	7 parts
Sulphur..........	2 parts
Chlorate of potash.	16 parts

White.—

I.—Gunpowder.......	15 parts
Sulphur..........	22 parts
Nitrate of potassium	64 parts
II.—Potassium nitrate...	30 parts
Sulphur...........	10 parts
Antimony sulphide (black)..........	5 parts
Flour.............	3 parts
Powdered camphor.	2 parts
III.—Charcoal..........	1 part
Sulphur...........	11 parts
Potassium sulphide.	38 parts
IV.—Stearine,..........	1 part
Barium carbonate . .	1 part
Milk sugar.........	4 parts
Potassium nitrate....	4 parts
Potassium chlorate.	12 parts

As a general rule, a corresponding quantity of shellac may be taken instead of the sulphur for inside fireworks.

The directions for using these solutions are simply to imbibe bibulous papers in them, then carefully dry and roll tightly into rolls of suitable length, according to the length of time they are to burn.

Fuses.—For fuses or igniting papers, the following is used:

Potassium nitrate...	2 parts
Lead acetate.......	40 parts
Water............	100 parts

Mix and dissolve, and in the solution place unsized paper; raise to nearly a boil and keep at this temperature for 20 minutes. If the paper is to be "slow," it may now be taken out, dried, cut into strips, and rolled. If to be "faster," the heat is to be continued longer, according to the quickness desired. Care must be taken to avoid boiling, which might disintegrate the paper.

In preparing these papers, every precaution against fire should be taken, and their preparation in the shop or house should not be thought of. In making the solutions, etc., where heat is necessary, the water bath should invariably be used.

PYROTECHNIC MAGIC.

[Caution.—When about to place any lighted material in the mouth be sure that the mouth is well coated with saliva, and that you are exhaling *the breath continuously*, with greater or less force, *according to the amount of heat you can bear.*

If the lighted material shows a tendency to burn the mouth, *do not attempt to drag it out quickly*, but simply shut the lips tight, and breathe through the nose, and the fire must go out instantly.

In the Human Gas Trick, where a flame 10 to 15 inches long is blown from the mouth, be careful after lighting the gas, *to continue to exhale the breath.* When you desire the gas to go out, simply shut the lips tight and hold the breath for a few seconds. In this trick, until the gas is well out, any inhalation is likely to be attended with the most serious results.

The several cautions above given may be examined with a lighted match, first removing, after lighting the match, any brimstone or phosphorus from its end.]

To Fire Paper, etc., by Breathing on it.—This secret seems little known to conjurers.

Half fill a half-ounce bottle with carbon disulphide, and drop in 1 or 2 fragments of phosphorus, each the size of a pea, which will quickly dissolve. Shake up the liquid, and pour out a small teaspoonful onto a piece of blotting paper. The carbon disulphide will quickly evaporate, leaving a film of phosphorus on the paper, which will quickly emit fumes and burst into flame. The once-popular term Fenian fire was derived from the supposed use of this liquid by the Fenians for the purpose of setting fire to houses by throwing a bottle down a chimney or through a window, the bottle to break and its contents to speedily set fire to the place.

For the purpose of experiment this liquid should only be prepared in small quantities as above, and any left over should be poured away onto the soil in the open air, so as to obviate the risk of fire. Thin paper may be fired in a similar manner with the acid bulbs and powder already mentioned. The powder should be formed into a paste, laid on the paper, and allowed to dry. Then the acid bulb is pasted over the powder.

Burning Brimstone.—Wrap cotton around two small pieces of brimstone and wet it with gasoline; take between the fingers, squeezing the surplus liquid out, light it with a candle, throw back the head well, and put it on the tongue blazing. Blow fire from mouth, and observe that a freshly blown-out candle may be lighted from the flame, which makes it more effective. After lighting candle chew up brimstone and pretend to swallow.

Blazing Sponge Trick.—Take 2 or 3 small sponges, place them in a ladle; pour just enough oil or gasoline over them to wet them. Be very careful not to have enough oil on them to cause them to drip. Set fire to the sponges and take one of them up with the tongs, and throw the head back and drop the blazing sponge in the mouth, expelling the breath all the time. Now close your mouth quickly; this cuts off the air from the flame and it immediately goes out. Be careful not to drop the sponge on the face or chin. Remove sponge under cover of a handkerchief before placing the second one in the mouth.

Burning Sealing Wax.—Take a stick of common sealing wax in one hand and a candle in the other, melt the wax over the candle, and put on your tongue while blazing. The moisture of the mouth cools it almost instantly. Care should be taken not to get any on the lips, chin, or hands.

Demon Bowls of Fire.—The performer has three 6½-inch brass bowls on a table, and openly pours ordinary clean water (may be drunk) into bowls, until each is about half full. Then by simply passing the hand over bowls they each take fire and produce a flame 12 to 20 inches high.

Each bowl contains about 2 teaspoonfuls of ether, upon which is placed a small piece of the metal potassium, about the size of a pea. If the ether be pure the potassium will not be acted upon. When the water is poured into the bowl the ether and potassium float up, the latter acting vigorously on the water, evolving hydrogen and setting fire thereto, and to the ether as well.

The water may be poured into the bowl and lighted at command. In this case the potassium and ether are kept separated in the bowl, the former in a little cup on one side, and the latter in the body of the bowl. The water is poured in, and on rocking the bowl it is caused to wash into the little cup, the potassium floats up, and the fire is produced.

N. B.—The above tricks are not safe in any but specially made bowls, i. e., bowls with the wide flange round edge to prevent the accidental spilling of any portion of the burning ether.

The Burning Banana.—Place some alcohol in a ladle and set fire to it. Dip a banana in the blazing alcohol and eat it while it is blazing. As soon as it is placed in the mouth the fire goes out.

Sparks from the Finger Tips.—Take a small piece of tin about ½ inch wide and 1½ inches long. Bend this in the shape of a ring. To the center of this piece solder another small piece of tin bent in the shape of a letter U; between the ends of this U place a small piece of wax tape about ½ inch long. Take a piece of small rubber tubing about 2 feet in length and to one end of this attach a hollow rubber ball, which you must partly fill with iron filings. Place the rubber ball containing the iron filings under the arm and pass the rubber tube down through the sleeve of the coat to the palm of the hand; now place the tin ring upon the middle finger, with the wax taper inside of the hand. Light this taper. By pressing the arm down sharply on the rubber ball, the force of the air will drive some of the iron filings through the rubber tube and out through the flame of the burning taper, when they will ignite and cause a beautiful shower of sparks to appear to rain from the finger tips.

To Take Boiling Lead in the Mouth.—The metal used, while not unlike lead in appearance, is not the ordinary metal, but is really an alloy composed of the following substances:

Bismuth......... ...	8 parts
Lead...............	5 parts
Tin................	2 parts

To prepare it, first melt the lead in a crucible, then add the bismuth and finally the tin, and stir well together with a piece of tobacco pipe stem. This "fusible metal" will melt in boiling water, and a teaspoon cast from the alloy will melt if very hot water be poured into it, or if boiling water be stirred with it. If the water be not quite boiling, as is pretty sure to be the case if tea from a teapot is used, in all probability the heat will be insufficient to melt the spoon. But by melting the alloy and adding to it a small quantity of quicksilver a compound will be produced, which, though solid at the ordinary temperature, will melt in water *very much below the boiling point.* Another variety of easily fusible alloy is made by melting together

Bismuth..........	7 to 8 parts
Lead.............	4 parts
Tin..............	2 parts
Cadmium.........	1 to 2 parts

This mixture melts at 158°, that given above at 208° F.

Either one of the several alloys above given will contain considerably less heat than lead, and in consequence be the more suitable for the purposes of a "Fire King."

When a body is melted it is raised to a certain temperature and then gets no hotter, not even if the fire be increased—all the extra heat goes to melt the remainder of the substance.

Second Method.—This is done with a ladle constructed similarly to the tin cup in a previous trick. The lead, genuine in this case, is, apparently, drunk from the ladle, which is then tilted, that it may be seen to be empty. The lead is concealed in the secret interior of the ladle, and a solid piece of lead is in conclusion dropped from the mouth, as congealed metal.

To Eat Burning Coals.—In the first place make a good charcoal fire in the furnace. Just before commencing the act throw in three or four pieces of soft pine. When burnt to a coal one cannot tell the difference between this and charcoal, except by sticking a fork into it. This will not burn in the least, while the genuine charcoal will. You can stick your fork into these coals without any difficulty, but the charcoal is brittle and hard; it breaks before the fork goes into it.

Chain of Fire.—Take a piece of candle wick 8 or 10 inches long, saturated with kerosene oil, squeeze out surplus oil. Take hold of one end with your fire tongs, light by furnace, throw back your head, and lower it into your mouth *while exhaling the breath freely.* When all in, close your lips and remove in handkerchief.

NOTE.—Have a good hold of the end with the tongs, for if it should fall it would probably inflict a serious burn; for this reason also no burning oil must drop from the cotton.

Biting Off Red-Hot Iron.—Take a piece of hoop iron about 2 feet long, place it in a vise and bend it backwards and forwards, about an inch from the end, until it is nearly broken off. Put this in a furnace until it becomes red hot, then take it in your right hand, grasp the broken end in your teeth, being careful not to let it touch your lips or your tongue, make a "face" as though it was terribly hard to bite off, and let the broken end drop from betweer your teeth into a pail of water (which you should always have at hand in case of fire), when the hissing will induce the belief that the portion bitten off is still "red hot"—it may be, for that matter, if the iron be nearly broken off in the first place and if you have good teeth and are not afraid to injure them.

Water Stirred Yellow, Scarlet, and Colorless.—Obtain a glass tube with one end hermetically sealed and drawn into a fine point that will break easily. Into an ale glass put a solution of mercury bichloride (corrosive sublimate, a deadly poison) and into the tube a strong solution of potassium iodide so adjusted in strength that it will redissolve the scarlet precipitate formed by the union of the two liquids. While stirring the solution in the glass the bottom of the tube (apparently a glass rod) is broken and a small portion of its contents allowed to escape, which produces a beautiful scarlet. The balance of the fluid in the tube is retained there by simply keeping the thumb on the open top end. Continue the stirring, allowing the balance of the contents of the tube to escape, and the scarlet fluid again becomes colorless. Before the scarlet appears the liquid is yellow.

To heighten the effect, another ale glass, containing only clean water and a solid glass stirring-rod, may be handed to one of the company, with instructions to do the same as the performer; the result is amusing.

Pyrotechny

by George W. Weingart

A PRACTICAL MANUAL FOR MANUFACTURERS OF FIREWORKS, SIGNALS FLARES AND PYROTECHNIC DISPLAYS

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George Washington Weingart

"The Man with Hat in Hand gets easily over the Land." So read the motto on the family crest of George W. Weingart's maternal ancestors of Nuremburg, Germany, whose name, Höflich, signified politeness and courtesy. His father's antecedents came from Weingarten, Bavaria, whose residents were nearly all artists, authors, or musicians. Born in Pass Christian, Miss. on July 14, 1871, George combined these inherited traits to become not only an accomplished musician, chemist, and pyrotechnist, but in later life the author of the most famous American book of the century on the manufacture of fireworks.

Although a talented violinist and cellist as a young man, his interest in pyrotechnics led him to study organic chemistry and to seek work at the A.L. Due fireworks factory in Cincinnati, where he learned the trade, later setting up his own shop in New Orleans. He continued making fireworks and handling public displays till the death of his father, when he gave up the business to manage the family toy store on Chartres St., but continued as official "torch lighter" for the Mardi Gras parades until two years before his death at the age of 77, during which time he wrote his famous book PYROTECHNICS, published in 1947, often called "the Bible of Modern Pyrotechnics". With the passing of George Washington Weingart II in New Orleans, Sept. 28, 1948, America lost one of its foremost authorities in the field, but his book remains as a lasting monument to "the Man with his Hat in his Hand".

INTRODUCTION

To those contemplating the making of fireworks, either professionally or as an amusement it is desirable to understand the principles which govern the operations of the various devices as well as the compositions of the chemicals entering into their production.

The principle of colored lights is based on:

1st. Producing a mixture that will burn at a reasonable speed while generating an intense heat,

2nd. Adding thereto the salts of such elements, in the spectrum of which, predominate lines of the desired colors.

Heat generating compounds consist chiefly of:

(a). Substances which yield oxygen freely when ignited in the presence of carbon, viz:

Potassium chlorate,
Potassium per-chlorete,
Potassium nitrate,
Sodium chlorate,
Barium nitrate,
Strontium nitrate.

(b). Carbon and carbonaceous sources, viz:

Charcoal,
Shellac,
Fossil gums,
Resins,
Asphaltum,
Dextrine,
Stearine,
Sugar of milk,
Corn flour etc.

In addition to the above there are some substances which when added to colored fire compositions increase the affinity of the several constituents for one another thereby improving the colors, viz:

Sulphur
Picric acid

and in the instance of blue and green fires it is almost essential to add an easily volatilized chloride in order to get sufficient depth of color.

viz: Calomel
Sal Ammoniac.

The exact function of these last named substances is not entirely clear but it appears that the best spectrums are yielded by the chlorides of the elements. However most chlorides are deliquescent and therefore unsuited to fireworks making. By adding a substance that yields chlorine freely at the moment of decomposition the necessary conditions are produced for obtaining the best results.

The following substances are most generally used for producing pyrotechnical colors.

PURPLE

Strontium and Copper compounds.

ORANGE

Strontium and Sodium salts.

Bright or "Plain" Mixings

Consist almost entirely of:

Saltpeter,
rarely Lead nitrate,
Sulphur,
Charcoal or lampblack.

with the addition of

Steel filings,
Iron borings,
Zinc powder,
Antimony,
Orpiment,
Realgar.

PINK

Calcium carbonate,

Calcium sulphate,
Calcium oxalate.

GREEN

Barium nitrate,
Barium chlorate,
Boric acid,
and rarely Thalium nitrate.

RED

Strontium nitrate,
Strontium carbonate,
and rarely Lithium salts.

BLUE

Copper carbonate,
Copper arsenate,
Copper sulphate,
Copper black oxid,
Copper & Ammonium sulphate,
Copper oxalate,
Copper & Ammonium chloride.

YELLOW

Sodium oxalate,
Sodium bicarbonate,
Sodium metantimoniate.

The intensly bright white sparks are produced by aluminum powder. At one time Magnesium was used for this purpose but it has been entirely discontinued.

PART I.

INGREDIENTS

SALTPETER

(Nitre—Potassium nitrate)

Specifications for saltpeter to be used in fireworks making call for a salt that is clean, white and should be ground fine enough to pass through a sieve of 80 to 100 mesh. It should contain less than 1% of sodium, calcium and magnesium salts combined.

POTASSIUM CHLORATE

K Cl O_3

For pyrotechnical purposes it should be white, odorless and contain not over ½ of 1% of sodium, calcium and bromine combined. It should be of the same fineness as saltpeter.

SPECIAL WARNING

Never mix dry potassium chlorate with red phosphorus, black antimony sulphide or sulphur. The mixture will detonate spontaneously with a shattering blast. Always moisten the potassium chlorate with water before mixing it with the above chemicals or anything else, just to be safe.

POTASSIUM PERCHLORATE.

K Cl O_4

This recently produced substance forms another valuable addition to the pyrotechnists art. Containing even more oxygen than the chlorate it is less liable to decomposition due to the fact that it is a salt of perchloric acid which is a much more stable acid than chloric from which the chlorate is derived. It can be substituted for the chlorate in most mixings and can be safely used in connection with sulphur.

SULPHUR.

The "flour of sulphur" which is used is almost white and comes in bags of 50 lbs. "Flowers" of sulphur is also sometimes used as well as coarsely ground sulphur which burns somewhat slower than the first two varieties. Specifications call for less than 1/10 of 1% of impurities and the finely ground should pass through a sieve of 120 mesh.

CHARCOAL.

Willow coal is the best for fireworks purposes through coal made from any soft wood is suitable. Pine coal is not very desirable. Charcoal that has a brown tint indicates incomplete carbonization and should be avoided. Also it should contain a minimum of grit. Shaking a sample in a bottle of water and decanting several times will disclose an excessive amount of sand etc.

LAMPBLACK.

To make a good bright star it should be free from oil or other impurities and it is sometimes necessary to bake it as will be explained later, in order to get rid of volatile impurities which impair its briliancy in burning.

SHELLAC

and other gums etc.

Shellac, a gum like substance, is the secretion of an insect living on a large variety of trees in northern India. After going through various processes it finally reaches this country in some dozen different grades.

For the best work shellac is almost indispensable but for stock goods, tableau fires and torches a number of substitute gums have been introduced such as Kauri; a fossil resin of a light yellow to a dark brown color, obtained from New Zeland. Red Gum comes from the Kangaroo Islands, 5 miles from Australia. K. D. dust is used for green fire. Asphaltum produces excellent colors when finely ground but owing to its containing sulphur, or perhaps on account of being so easily decomposed it is liable to cause spontaneous combustion when mixed with potassium chlorate. A mixture of these will explode violently when struck with a hammer on an anvil. With potassium perchlorate, however, it is entirely safe. The Syrian Asphaltum is the best. So called Green Gum is merely powdered coconut shells and has no more value in pyrotechny than sawdust. Flour, dextrine, sugar of milk etc. are also frequently used as sources of carbon. Another article of this character is

STEARINE.

In making blue fire it has been found that stearine produces a better effect, especially with paris green and other copper salts, than most any of the other hydrocarbons. It is mostly obtained in cakes and is reduced to a servicable condition by setting a carpenter's plane upsidedown over a box and shoving the cakes against the blade so as to shave the stearine as fine as possible. When it is then mixed with the other ingredients it will pass through an ordinary sieve.

STRONTIUM NITRATE.

It is probably the most useful color producing chemical used in fireworks making, as the deep red light which it gives is the most marked effect which the pyrotechnist has achieved. Owing to its deliquescent properties, however, a number of methods have been devised to overcome this tendency one of which is to melt in an iron pot over a fire some shellac and stir in the nitrate of strontia, cooling and pulverizing. Another plan is to use carbonate of strontia but at the cost of considerable depth of color. Strontium nitrate is used in a somewhat coarser powder than the potassium salts but should be a clean white and contain not over 1/5 of 1% moisture and ¼ of 1% sodium salts.

STRONTIUM CARBONATE

In damp climates there is no alternative but to use this strontium compound for most exhibition work as a piece of lancework made with nitrate of strontium, if exposed for one hour to a damp atmosphere, will hardly burn. Precipitated carbonate of strontium is the only kind which should be used and may be purchased for about 16c lb. or can be easily made by adding carbonate of ammonia to a solution of strontium nitrate, thoroughly washing and drying the precipitate. If sodium carbonate is used as a precipitant it is almost impossible to remove every trace of it from the carbonate of strontium and causing an orange tint to the red light.

BARIUM NITRATE

As a color producer it is far inferior to strontium though it does not attract moisture. If used without calomel its color is so pale as to be almost indistinguishable from white. Specifications for fireworks making are practically the same as for strontium nitrate. A better salt for making green fire is

BARIUM CHLORATE

This salt give a very beautiful emerald color but its high cost, viz: about 30c lb. makes it little used except in exhibition work. Some recipies have been given for green fire using boracic acid, thalium salts etc. but if used at all it is to a very limited extent. All barium salts are very poisonous.

SODIUM OXALATE

It is a strange fact that while yellow is the most common color of fires in general its practical production in pyrotechny is accompanied with some difficulty from the fact that there is practically only one insoluble salt of sodium while all the others are more or less hygroscopic. The nitrate and bicarbonate give deep yellow lights but the least dampness will render them incombustible and even the oxalate, will in damp weather, attract moisture. The exception is Sodium met-antimoniate but as this salt costs $4.00 lb. and at best gives a pale color, it is not much used. Oxalate of soda costs about 20c lb. or can be easily made by adding bicarbonate of soda to a hot concentrated solution of oxalic acid. A copius precipitate falls which however cannot be washed but must be dried on a filter. An excess of oxalic acid should be maintained in this operation.

COPPER ARSENITE

(Paris green)

This article is made in New York state and elsewhere in this country and can be bought for from 10c to 15c lb. from dealers in painters supplies. It can also be easily made by adding a solution of blue-stone to one of arsenius acid, washing and drying the resultant bulky precipitate. It is used in making blue fire. The kind used for green paint is entirely satisfactory for fireworks making.

COPPER, Black Sulphide

This compound is valuable in the production of blue and purple fires when used in conjunction with calomel. It is important to note in this connection that the product made by fusion only, is of value in pyrotechny. The precipitated black sulphide is useless. As it is sometimes quite difficult to obtain the above product while it is very easy to make, the following method is advised.

Procure some thin sheets of scrap copper and cut them into pieces about 1 inch square. Take a large clay crucible and pack it with alternate layers of the copper scraps and ground sulphur to within an inch or so of the top. Cover and place in a bright red fire for about an hour. When removed and cooled the contents may be shaken out and ground or pulverized for use, screening through a 60 to 80 mesh sieve. Exact proportions of sulphur and copper are not necessary as the excess of copper burns off in fusing.

COPPER, Black Oxide

This is used similarly as the above and it is more easily obtained. The fused form must be used as the brownish light precipitated oxide is useless in fireworks making.

COPPER CARBONATE

This substance is also used for making blue fires but better effects are obtained by the use of other copper compounds, with less trouble. The native carbonate is almost useless for fireworks purposes but the precipitated is easily obtained from dealers in pyrotechnical chemicals or can be made by adding carbonate of ammonia to a solution of blue-stone. Chertiers Copper is made by carefully adding aqua ammonia to a solution of blue-stone, evaporating and chrystalising. Black sulphuret of copper, black oxide of copper and various other copper compounds are occasionally used. The author has obtained the best results with copper ammonium chloride, and calomel is unnecessary with this salt.

COPPER SULPHATE

For most purposes where a good blue was required for exhibition purposes the older pyrotechnists used this salt but owing to its being a sulphate great care must be used in mixing it with chlorate of potash and a separate sieve should be used for mixtures of these substances, which should not be employed in any other work. It costs usually 10c to 15c lb. Mixtures containing it must not be stored but used promptly after making. Exposure to moist air oxidizes this and releases sulphuric acid. This can be obviated by using potassium perchlorate but the resulting mixtures are much more difficult to ignite in the form of stars etc.

ANTIMONY

Metalic or Reglus antimony, when finely powdered in an iron mortar is used in making white fire.

ANTIMONY SULPHURET.

(black)

If 70% pure it is still servicable for pyrotechnical purposes and is used for making white fire, maroons and smoke effects. Red and orange sulphurets are also sometimes used. The compounds are poisonous.

RED ARSENIC, (REALGAR)

$As\ S_2$

ORPIMENT

$As\ S_3$

They are useful in making white stars, especially as these take fire far more easily than those made from antimony. Arsenic compounds are also used for making yellow smoke in day fireworks.

ALUMINUM.

When, about 50 years ago, it was found that a star of unusual briliancy could be produced by the use of magnesium this metal suddenly came into considerable demand in spite of its then cost of $75.00 lb. About the time that its price was reduced to $5.00 lb. it was found that aluminum was in every way better and cost little more than $1.00 lb. in fine powder. It can now be gotten from most paint dealers, in 1 lb. cans or papers at 60c lb. Aluminum powder should be 95% pure. It may contain 2% fatty meterial and 1% silicon. The fine should pass through a 100 mesh sieve and the flake, through a 50 mesh sieve.

CALOMEL.

This is used to deepen the color of fires when they are not sufficiently deep without its use. It has been found that the chlorides of metals give the best spectrum but chlorides are not usually practical for fireworks making so the addition of an easily decomposed chloride to fireworks compositions is to produce a chloride at the moment of combustion, thereby acquiring the desired result. Finely divided metals also take fire spontanously in chlorine gas and the great heat thereby produced probally causes the increased depth of color.

AMMONIUM CHLORIDE.

Sal Ammoniac.

This is sometimes used as a substitute for calomel but its affinity for moisture seriously interferes with its general use. The crystalized salt is almost useless.

DEXTRINE.

In all the old works on pyrotechny, either a solution of shellac in alcohol or gum arabic in water is used to bind compositions for making stars and other similar purposes, but at present, in most cases the necessary amount of dextrine is added at once to the mixture and then nothing but water is needed to form it into the desired objects. Dextrine also improves the color of some fires and it may be advantageously used in place of glue for light work. Potato dextrine usually comes in sacks of about 200# and costs from 2½c to 5c lb. When used for gumming rocket sticks, tabs etc. it is simply mixed with water to the desired consistency. The light brown #152 is most suitable for pyrotechny.

GLUE.

Several forms of glue are used in fireworks making. For attaching lances to frame work a good grade of carriage glue is best. For attaching mine bottoms etc. to the cases cheap carpenters glue will suffice. For placing shell fuses and securing the ends of cannon crackers, good liquid glue is most convienent.

GUM ARABIC.

In powdered form this is used in some star compositions, especially for making Japanese Stars. It is also used in "Son of a Gun" composition.

STEEL FILINGS.

Cast iron borings etc.

A beautiful scintilating effect is produced with steel filings used in various ways. The Japanese make a little tube of twisted paper, at one end of which is a composition which when lighted produces a glowing bead of molten flux. The balance of the tube contains steel filings, which when reached by the fused bead, burst into feather like flashes. In other countries steel filings are added to gerbs, fountains and driving cases with resulting brilliancy. A beautiful waterfall effect is produced by charging from 50 to 200 cases 2 inches in diameter and 12 inches long with a composition containing cast iron borings. These are fastened to scantlings at intervals of about 15 inches, each scantling holding about 16 gerbs. These are matched and hoisted to a wire cable some 50 feet above the ground. When burned the effect is most realistic as the arc of the suspended wire gives just the right curve to cause the appearance of perspective while the roar of the burning gerbs is also characteristic of Niagara Falls as the fire from the iron borings drops to the ground.

The best steel filings for gerbs is known as "needle steel". This resembles broken sewing needles but is really a by-product of some turning or planing operation. The steel filings from saw filing shops are quite good provided they are the result of hand filing and not the particles thrown off by emery wheels, which are useless for pyrotechnical purposes. When steel filings are added to gerb compositions, the saltpeter quickly attacks them, frequently causing the gerb to become quite hot. The steel is rusted and this action practically destroys its usefulness. To prevent this the steel must be coated in some way that the saltpeter cannot attack it which may be accomplished as follows:

In an agateware saucepan place a piece of paraffin and carefully melt it, heating as much as possible without permitting it to smoke. To this add clean steel filings, as much as the paraffin will thoroughly coat. There should be no surplus of paraffin but just enough to completely cover each filing. Shake the pan and stir frequently while cooling to prevent the filings from caking. Steel filings are also used for stars in rockets and shells.

CLAY.

This is used for closing the ends of most cases as well as choking them when they are not crimped. Most any kind of clay will do. It must be thoroughly dried, pulverized and sifted. Before using, it may be slightly dampened.

GUN POWDER.

This is used in all grades from Dupont FFF Rifle to the coarse grains as large as cracked corn, for shells. A slow burning powder is preferable for a driving charge as it reduces the liability of shells bursting in the mortar

MEAL POWDER.

This article is used considerably in display work for gerbs etc. and in shells and rockets as a blowing charge. It is generally supplied in 25 lb. wooden kegs but is sometimes difficult to obtain. In that case some pyrotechnists make a fairly good article themselves, as follows:

Mount a 50 gallon wood barrel on two uprights so that it will revolve freely on centers fastened to the heads. On one center attach a crank and cut a hole (closed by a suitable plug) into side of barrel for putting in and removing the necessary ingredients. Place in the barrel 300 to 500 lead balls about one inch in diameter. When it is desired to make meal powder put into the barrel a thoroughly mixed composition as follows:

Saltpeter, double refined	15 lbs.
Willow charcoal	3 "
Sulphur flour	2 "

The barrel is now revolved for about 500 turns. The longer it is turned, the stronger the powder will become Great care must be exercised to see that no foreign matter such as nails, gravel etc. find their way into the barrel as this might result in an explosion.

New Ingredients.

Some years ago powdered magnesium was added to the ingredients used in pyrotechny and very fine bright effects were produced with it. Just when its high price and its affinity for oxygen, causing it to decompose the chemicals with which it was mixed, made pyrotechnists look at it askance aluminum came on the scene. Added to stars and torches it greatly increases their brilliancy and beauty. Exquisite water fall effects are produced with it as well as comets, tailed stars and intensly bright flares. Large quantities of finely divided aluminum (pyro aluminum) are used in the new "flash crackers" and the same composition is used in maroon shells. Besides increasing the report it gives a startlingly bright flash to the explosion. Being unaffected by water it is likewise much safer than magnesium but care should be used in handling it because as, before mentioned all finely divided metals are liable to explosion when in contact with oxygen producing chemicals. Rubbing into it a small amount of vaseline seems to reduce the danger of accident.

Picric acid is another valuable ingredient in fireworks making. When added in small quantities to colors it deepens them and increase their brilliancy without making them burn much faster. Also beautiful colors can be produced with it, almost free from smoke. But it must always be kept in mind that picric acid (tri-nitro-phenol) is a first cousin to T N T the tremendous explosive force of which is only too well known. For this reason it cannot be used in shells as stars made with it will detonate when confined, instead of burning. Another effect for which large quantities of picric acid were used until some years ago when a fatal accident occured in a factory employed almost exclusively in making them are the amusing "whistling fireworks". Picrate of potash has the peculiar property of emiting a shrill whistling sound when rammed tightly and burned in a small tube. If made in small quantities and carefully handled it seems to be reasonably safe but the result of a barrel of it accidently detonated can be readily imagined.

Still another substance producing a most beautiful effect when fired from specially prepared rockets, as will be explained later in detail, is phosphorus. It is with this that the so called "liquid fire rockets" are made and a more beautiful display than these does not exist. They consist of an intensly yellow flame melting as it falls through the air, breaking into myriads of incandescent particles with a heavy background of white smoke. Obviously, the greatest care must be exercised in its use as phosphorus burns, even when very small are most painful, but when properly handled it is no more dangerous than many other articles.

Considerable quantities of phosphorus are also used in the manufacture of the article variously known as "spit devil" "son of a gun", "devil on the walk" etc. but deaths of children by poisoning on account of mistaking these tablet looking contrivances for candy and eating them has caused their restriction in some states.

Amorphous phosphorus is the base of most of the toy torpedoes in use. Fulminate of silver was used almost exclusively for this purpose 40 years ago but only a small amount is used now owing to its very sensitive nature. However, its method of use and preparation will be given later as a matter of record.

Zinc powder is used to some extent for making what is known as Electric Spreader Stars. These produce an original effect, breaking up while burning into many small bluish-green particles. These, being propelled with considerable force give the appearance of electrical discharges, hence the name. On account of the explosive nature of zinc dust the making of this star must be done with caution and reserve, until it is well understood.

An effect that is always beautiful, is easily produced, is perfectly safe under all circumstances and is susceptible of an infinite variety of uses is the Japanese or lamp-black star. The well known Willow Tree rockets and shells are made with it and it may be used as garniture for colored rockets, mines etc. An unusual fullness is given to any article to which a small quantity of Jap. star is added.

PART II.

MANIPULATIONS

The handling of explosives, naturally, is never entirely free of danger. No more so is electricity, gasoline and many other things in daily use yet many persons have devoted long lives to the making of fireworks without having an accident. Even with the greatest care, however, accidents will occur to both those employed in making fireworks as well as those burning them. It is here endeavored to point out the most fruitful sources of accident though obviously it is impossible to foresee every instance in which some carelessness or unknown factor may bring on disaster.

First, always keep separate places, a considerable distance apart to be used for making so-called "plain mixings" as rockets, romancandle and gerb composition containing sulphur, and the colored mixings containing chlorate of potash. Separate sieves and utensils of every description must be employed and those working in the "plain" sections of the factory must not go into the rooms of those in the "colored" sections.

Second, keep in mind that very slight friction will sometimes start the burning of mixtures of finely divided chemicals. Star composition has been known to explode while being sifted, by scratching the brass wire sieve bottom with the finger nail, while rockets have taken fire from the brass solid rammer striking the top of the spindle while ramming.

Third, finely divided metals, when in contact with chlorate of potassium sometimes take fire suddenly. While fortunately this is seldom the case it must not be lost sight of. Even steel filings and iron borings frequently become quite warm when mixed with saltpeter etc. and rammed into gerbs. Fire is said to have occured from this action. The prevention of this has been explained under "Steel Filings".

Employes in the mixing and ramming rooms of factories should be required to wear rubber shoes while at work and a constant source of danger is the carrying of matches. This cannot even be controlled by requiring the employes to change their clothes in the factory before going to work and having them wear garments without pockets as they will sometimes slip out for a smoke during rest hours and have matches secreted somewhere about their persons.

Small buildings should be supplied, about 12 feet square and not less than 50 feet apart for all those engaged in mixing and ramming operations as well as for those making stars and as much as possible have one person to a room. Doors should be placed at both ends of work rooms and should always open to the outside with no fastenings on the inner side but held closed, if desired, by spring hinges. Fire buckets, inspected daily should be on each building, supplemented by fire hose convienently placed for emergency.

The most successful method of reducing the liability of serious accidents to a minimum is to keep at all times the least possible amount of composition on hand in the work rooms and to remove to storage or finishing rooms all rammed articles as quickly as they accumulate.

Long experience has shown the following list of mixtures used in pyrotechny to exhibit the characteristics following each and are to be handled accordingly.

SALTPETER, SULPHUR, CHARCOAL and LAMPBLACK seem to be the safest combinations with which we have to deal, accidents with these accur only when a spark has been struck in some manner and brought in contact with mixtures of them.

BARIUM NITRATE with sulphur, saltpeter and aluminum are not reported to have caused any accidents.

BARIUM and STRONTIUM NITRATES, ALUMINUM and similar substances in combination with POTASSIUM PER-CHLORATE have been found to be among the safe mixtures even when mixed with sulphur and gums.

Barium nitrate and Strontium nitrate when in combination with potassium chlorate and shellac or other gums form a sensitive mixture and this condition is largely increased when powdered charcoal is added. Care is therefore urged to avoid all unneccessary friction when handling same.

BARIUM CHLORATE yields its oxygen quite readily so it is to be handled with great care in compounds containing shellac and other hydrocarbons.

ALUMINUM powder in mixtures with potassium chlorate, barium nitrate and shellac or other carbon sources are classed as "hazardous".

Mixtures of potassium chlorate with sulphur, sulphates or sulphides are to be avoided at all times. Chlorates should never be mixed with ammonium salts as this combination is said to be liable to spontaneous combustion.

Potassium bi-chromate and permanganate are to be handled with care, especially in combination with finely divided metals.

Mixtures of picric acid and chlorates are too sensitive for ordinary use.

Compositions of potassium chlorate and phosphorus must never be mixed except under water. Phosphorus alone must never be removed from water for more than a few moments at a time, and then handled so as to avoid all friction.

FULMINATES of MERCURY and SILVER should only be handled by experts.

When care is urged in the foregoing combinations it does not refer to small amounts used by a person of ordinary judgement but more specifically to amounts of 10 to 100 pounds when thoughtlessly handled as so much sand or cement.

When experimenting with new substances use the smallest possible amounts of the component chemicals until the entire safety of the mixture is assured. Before using considerable quantities of new mixtures they should be subjected to exhaustive tests as friction, percussion, detonation and moisture with subsequent drying. Also their flash point should if possible be ascertained with suitable apparatus for this purpose.

MIXING.

WARNING
READ THIS!

It is not sufficient for the pyrotechnist to know what mixtures of various substances will produce the effect which he desires; he should also understand the *reason* why these effects accrue. For instance, he may know that a mixture of saltpeter, sulphur and charcoal will explode when a lighted match is brought in contact with it, but he should also know *why* it explodes.

Broadly speaking practically all pyrotechnic compositions owe their action to chemical decomposition. This may occur under four different conditions; namely rotting, burning, explosion and detonation. The second and third of these are made use of most frequently by the pyrotechnist. The last, with a few exceptions, he tries to avoid while the first is of no value to him.

Rotting is a slow process, usually produced by fungus and bacteria aided by moisture and slight heat.

Burning proceeds very much faster and one of the objects of the pyrotechnist is to control its speed.

Explosion is due to a violent combination of the chemical elements which combine easily with one another and is usually brought about by the application of heat. Heat may arise from fire, friction or spontaneous combustion.

Detonation is an instantaneous decomposition of the substances involved, in which their component elements change place with the utmost violence. This property is made use of in blasting with dynamite, etc. where the greatest possible energy is desired from the substances involved. It is brought about mostly by the use of fulminates which detonate when ignited. Dynamite, when lighted simply burns but when a small amount of fulminate is detonated in its midst the action is communicated to the dynamite and the resultant violent action is produced.

Chemical action results from the attraction of different elements for one another. For instance: if one part by weight of oxygen and 2 parts of hydrogen are mixed at ordinary temperatures nothing occurs; but if a spark or other source of energy as sunlight is allowed in their midst the reaction proceeds to a point where the mixed gases combine with a violent explosion and water is produced. This principle applies throughout to practically all pyrotechnical mixtures.

Explosive Hazards

This is the "headache" of the pyrotechnist. The elements of some chemicals are so loosely combined that they fly apart at times without the direct application of heat. One such is potassium chlorate, one of the most useful fireworks chemicals. This is due to the fact that its acid component, viz; chloric acid, is an unstable compound and very easily dissociated. Consequently only a slight rise in temperature is sometimes sufficient to bring about an explosion. In the presence of sulphur, sulphides, sulphates, etc., which through oxidation sometimes produce minute quantities of sulphuric acid, this tendency is very strong. Consequently, compositions containing these substances must be strictly avoided.

Finely divided metals combine with oxygen easily and sometimes react sufficiently at ordinary temperatures to cause fire. Aluminum and zinc are instances of this danger.

STRICKING FIRE is another cause of danger against which the pyrotechnist must be on constant guard. This is usually due to steel tools being struck together in presence of easily ignited compounds. Sometimes, brass tools and even wooden parts produce enough friction to cause fire.

The first operation in fireworks making and I may say the most important is mixing. Chemicals are so well made now and can be so easily obtained in a powdered state that long articles on purifying, powdering etc. are unnecessary. All chemicals should, of coarse, be obtained of the best quality procurable at a reasonable price and as finely powdered (as a general thing) as possible but chemically pure drugs are not necessary.

For mixing on a small scale, round brass wire sieves are the best. For lances and the more particular work #22 to #26 mesh may be used while for plain making #16 to #18 mesh is suitable. If 25 lbs. or more of composition is to be mixed ordinary painted wash tubs are most convienent and the sieves should be made so as to just fit inside the upper edge of same while for mixings of from 100 lbs. up troughs are often used. For these, the sieves are made square and fit just inside the troughs, same as with tubs. Mixing machines are sometimes used for bright work or mixings containing no chlorate of potash but they are too dangerous for colors.

With the plain mixings, the coal is weighed first and put into the bottom of the tub; then the sieve put in place and the sulphur, saltpeter etc. pushed through it. When everything is sifted, bare the arms and mix well in every direction. Place the sieve on another empty tub of same size and sift from the first tub into the second one, a scoopful at a time. When all has passed through for the second time repeat once more into the first tub, mixing between siftings and after last sifting. For ordinary compositions this is sufficient but some mixtures are passed four or five times through the sieves.

In colored mixings more care must be observed and each ingredient sifted separately the first time, except the shellac, coal etc. which can be put right into the bottom of the tub. Never throw the chlorate of potash on the sieve at the same time with dextrine or other hydrocarbons but sift the potash first and add other salts one by one. Great care should be taken never to let the fingernails strike the sieve while sifting as it is very easy to "strike fire"from such causes, with disastrous effect as sharp star compositions in a loose state are almost as explosive as meal powder. Special mixings will be described when we come to the compositions requiring them.

CASE ROLLING.

This is the next most important operation of the business and the one requiring probably the most mechanical skill judging from the time required to learn it and the comparatively small number of really good case rollers to be found in most factories.

All kinds of fireworks require a case of some kind except tableau fires. A good case must be tightly rolled and almost as hard as iron. The best arrangement for case rolling is a sort of large desk made of tongue and grooved flooring tightly joined and firmly nailed to sills of about 2 inches thickness and tapering from 2 inches in front to 6 or 7 inches in the back so as to form a gentle rise from front to rear. According to the work to be done the rolling board may be made from two to four feet wide. See Fig. 1. A marble slab also is good for rolling rocket cases.

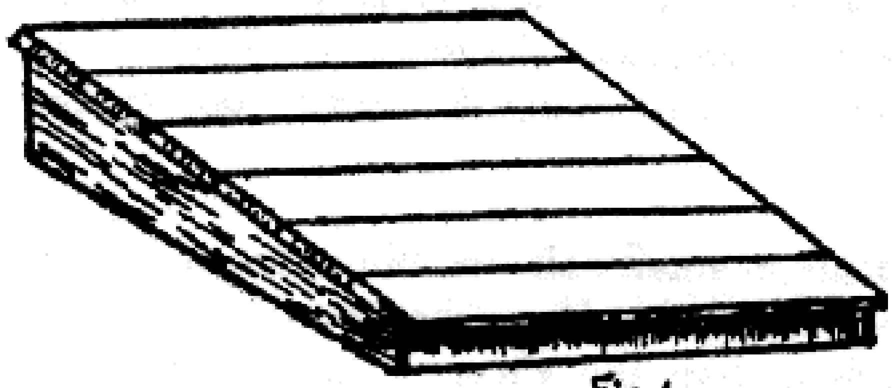


Fig. 1

Most cases are rolled from strawboard, featheredged. The best is made in Elbridge, N. Y. and comes in sheets 26" x 38" with weights varying from 40 to 150 sheets to bundle of 50 lbs. For rockets, two or three turns of hardware or cartridge paper are used first, backed up by five or six turns of strawboard. The cartridge paper being waterproof swells and contracts but little in rolling while the strawboard, being absorbent swells considerably; therefore when the strawboard is rolled on the outside of the case, it contracts in drying and is shrunk on making a very firm case. Heavy manilla and so called cotton sampling paper also make good rocket cases if carefully rolled but as these shrink considerably in drying, the ramming tools are liable to stick unless specially adapted to this kind of paper. The recently produced "Kraft" paper should make an excellent case though I have never used it. There is also a greyish rag paper which is extensively used for candles.

Since this was written the use of waste paper board has taken the place of strawboard for most fireworks cases. This is made in similar weights and sizes and used in the same manner.

The lightest cases used in fireworks making are lance cases. Some pyrotechnists use poster paper of different colors, corresponding to the color of the composition to be rammed into them, while others use linen paper.

Colored paper has the advantage of making lances easily distinguishable in case the boxes containing them become mixed. On the other hand it requires keeping a larger stock of empty cases continually on hand which is sometimes inconvenient. Linen paper is much stronger and only one kind is required, the different colors of lances being kept separated by having boxes for them with the colors marked on the outside.

Lances are made from ¼" to ⅜" in diameter and from 2½" to 4" long. Generally speaking, the greater the diameter, the less need be the length. I generally use a lance ¼" diameter made of ribbed linen paper 17" x 22" about 16 lbs. to the ream, cut in four, the smallest way or across the ribs and six times the long way or with the ribs. This makes 24 cuts from each sheet 3⅝" x 4½". Now procure a brass or copper tube with an outside diameter of ¼" and some good paste. Take a little bunch of say one or two dozen sheets and lay them squarely before you on the rolling board so that the 3⅝" sides are at top and bottom and holding them down tightly with the left hand, rub them gently toward you with the thumb nail of the right hand so that each one will slide about ¼" below and to the left of the one under it. Apply paste to these edges, lay the tube now on the top sheet about ¾" from the bottom of same and ⅜" from left or pasted edge. With the ends of the fingers of the right hand bend the lower edge around the tube, laying over about ¼" and roll to upper pasted end. Then with a turn of the fingers twist the bottom in. The bottoms should not be made too solid and if even a little hole is left in them it will be easier afterwards to stick them on the pins. Sometimes when an exhibition is made on the grounds and not subject to much handling, the lances are made without any bottoms. They may now be thrown lightly in a basket or sieve to dry. These operations while very simple are quite hard to describe and a few moments of practical demonstration will go farther than several pages of description.

Pin wheel cases and match pipes are rolled in a general way the same as lances, except that no bottoms are made to them and brass or steel rods are used instead of tubes. The most convienent size for match pipes is one yard in length and ¼" diameter. Use a good quality of manilla or kraft paper 24" x 36", 20 lbs. to ream. The quire is cut the longest way of the sheet, into stripe 4" to 5" wide. A steel rod four feet long is the best for rolling them. Pin wheel pipes are usually made 12" long and 3/16" diameter. Sometimes one end is made slightly funnel shaped by pasting a strip of paper 6" long and 2" wide at one end tapering to ½" at the other, rolled around the end of the rod. Rolling match pipes properly is one of the most difficult operations to master, in the business. It is therefore advisable to begin on shorter pipes until practice is acquired.

ROMAN CANDLE CASES.

These are also somewhat difficult to roll. It is almost essential to have feather edged boards for this work and preferably strawboard. The sheets for one to four ball candles are pasted entirely over with rather thin paste. From six ball up, only about 4" on each end of the sheet should be pasted on both sides. The manner of proceeding is to lay a sheet on the rolling board, pretty well up near the top, and upside down. Then with a 4" flat paint brush apply thin paste quite heavily on about 4" of the top of the sheet and about the same amount on the bottom. Now place another sheet on top of this but about one inch lower down, so that an inch of the first one extends beyond the next on top of it. Paste as before and repeat the operation until a dozen or more sheets are in the pile. Now reverse the entire lot at once so that the former bottom one will be on top. Paste over the bottom and top edges of pile now exposed and rub off surplus paste with a scrape of the rod and you are ready to begin rolling. (Fig. 2).

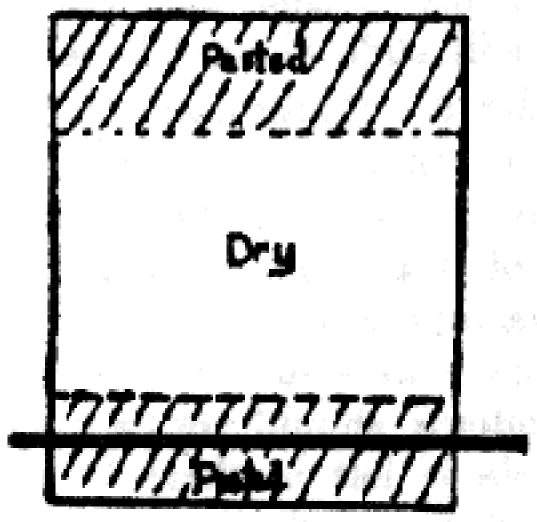


Fig. 2.

Lay the rod across the pile about 3" from the bottom. Lift bottom edge of first sheet, lay it over rod, draw rod with paper around it back, until edge of strip is on top of rod and by sliding the fingers along the rod and edge of sheet until same sticks firmly to it, for its entire length. Now roll firmly along, one hand following the other until the whole sheet is rolled up, care being taken that the case does not run to one side. By a quick backward twist of the rod it may now be removed from the former and placed on rack for drying.

The diameters and lengths of roman candles has been changed and reduced so often of late years that no standard of sizes can be given but the following will be found to be as useful as any for the average work and may be used comparatively. Special sizes may be easily adapted to the required circumstances. When cutting paper for candles and other cases as well care should be taken to always cut so the case rolls with the grain of the paper and with the feather edge at the top of the sheet.

NO.		LENGTH	BORE	SIZE OF SHEET	NO. OF STRAWBOARD
1	ball	4½"	5/16"	4½" x 6"	140
2	"	5½"	"	5½" x 7"	"
3	"	6½"	"	6½" x 8"	"
4	"	8½"	"	8½" x 10"	"
6	"	12"	⅜"	12" x 13"	"
8	"	15"	"	15" x 16"	"
10	"	17"	7/16"	17" x 20"	"
12	"	19"	"	19" x 20"	"
15	"	22"	½"	22" x 26"	120
20	"	26"	"	26" x 26"	"
25	"	32"	"	32" x 26"	100
30	"	36"	"	36" x 26"	"

Cases for rockets, gerbs, fountains, tourbillions, saxons etc. and the small paper guns used for mines, floral shells etc. require considerable skill and strength for rolling, especially the larger sizes. After seeing a great many case rollers at work and employing at different times their various methods, I have come to the conclusion that the following is not only the easiest but makes the best case.

Procure a small hair scrubbing brush of good quality and long stiff hair. Have the paste somewhat stiffer than for candles. Lay the sheet of strawboard on the rolling board, (in the case of rockets, with the sheet of cartridge paper on top of it.) Now, with the scrubbing brush rub some paste evenly over the cartridge paper, (not as much as for candles) and immediately roll up as tightly as possible, except the last two inches or so. Now paste the sheet of strawboard over as you did the cartridge paper and place the partly rolled case on top of it about 2" or 3" from the end nearest you, seeing that the edges of both are even. Raise the end of the strawboard projecting behind the already partly rolled case and bend it around so it will lay between the part of the cartridge paper left unrolled, and continue rolling, pressing meanwhile the case firmly to the rolling board or marble slab until the case is completed. This leaves a case that is already half dry and when completely so, should be firm enough that it cannot be bent in on the ends with the fingers. The advantages of this method of rolling heavy cases is that the paper, especially the strawboard has not the time to become softened and swelled up as when a number of sheets are pasted down at once, and a tighter, cleaner and more easily and quickly dried case results. If too much paste is used, when the case dries the water from the paste evaporates, leaving the case spongy.

The sizes of rockets vary as much as those of candles consequently the following list can only be used approximately:

Size	Length	Bore	Length Sheet Strawboard	No. Stw. Brd.	Hdw. Paper
1 oz.	3½"	⅜"	10"	140	
2 "	4"	"	13"	"	
3 "	4½"	"	17½"	"	
4 "	5"	½"	20"	120	
6 "	6"	9/16"	13"	"	12"
8 "	7"	⅝"	18"	"	"
1 lb.	8"	¾"	20"	"	17"
2 "	9"	⅞"	26"	140	25"
3 "	10"	1"	26"	120	"
4 "	11"	1¼"	"	"	50"*
6 "	13"	1½"	52"*	"	50"*

* These can be convienently used in two lengths.

Mine Cases.

No.	Height	Diameter	No. Strawboard	No. Pieces
1	4"	1½"	140	1
2	4¾"	1 11/16"	120	1
3	5½"	2 1/16"	100	1
4	7"	2¼"	100	2
5	8½"	2⅜"	100	3
6	10"	2¾"	100	4

Floral Shell Guns.

No.	Height	Diameter	No. Strawboard	No. Pieces
1	9"	2 5/16"	100	3
2	11"	2 11/16"	100	4
3	13"	3 3/16"	100	4
4	15"	3½"	100	5

Gerbs.

Length		Diameter
9"		¾"
11"		1"
13"		1¼"
15"		1½"
15"	Niagara Falls	2"

SHELL CASES.

These, though not being rolled (except the canister shell cases) properly come under this division as they are part of the case rollers' business, to make and are composed of paper and paste.

There are two ways of making them. One, roughly speaking, consists of papering the inside of a hole; the other, papering the outside of a ball. We will take a six inch diameter shell as an example to work on as it is the most popular size and same method is employed for all. First procure a perfectly round ball of wood or some other substance, five inches in diameter. We then cut stripe of strawboard and tagboard or heavy paper of most any kind, about ¾" wide and 4½" long and paste them on a board, one on top of another, with so much paste between them that they will not stick together but will become soft and pulpy. I have used a sort of red building paper sold in rolls, which made a better case than any other kind I ever used. The strawboard and other paper should not be pasted in the same pile but two piles made, one pile of each kind.

Now smear the ball or mold well with paste so it will be wet enough to keep the paper from drying and sticking to it before shell case can be finished. Then take strips of paper from either pile first and lay them on the mold, beginning on top and running half way down the side. Lay the second strip so it will lap over the first one about ¼" at the lower end and almost over it on top but ½" lower down. The third strip should start still a half inch further down from the top while the fourth strip again starts at the top. This will prevent the shell case from becoming egg shaped. Continue this until the entire upper half of the ball has been covered with paper. Each strip must be firmly pressed down and all surplus paste squeezed out with the fingers. Now repeat the operation as before but using the other paper. The object is to make it easier to see where one layer has begun and the other ended as each layer is put on. Another way is to cut the strips a foot long and after softening with paste as above, lay them on the mold from the top to the middle, tearing off the strip at the required point and letting second and third pieces start half an inch below the other so as not to get the top too thick as explained above.

After the third layer has been put on one should be laid on crosswise, crossing as much as possible the first layers. This process is continued, pressing each strip as firmly as possible until the case is about ⅜" thick at the edges where it is usually thinest, and not over ⅝" on top. If the work has been properly done the half shell can now be slipped off and allowed to dry. When dry the lower edge should be trimmed off with a sharp knife at a point that will make two halves, when put together show a fair sphere.

The other method is to have a wooden block hollowed out so as to have a hole in it 5½" in diameter and a perfect semi-sphere. Or a mold may be made by taking a ball of this diameter, oiling it well and setting it halfway of its diameter into a box of wet plaster of paris. Now then, proceed as before, except pasting the strips inside the hollow instead of on the outside of the ball. This will make a better looking shell and I believe, a stronger one when properly done. The paper may be cut into strips a foot or more long and torn off as they reach the edge of the hollow. In this way all waste is avoided and the rough edge made more even and regular. The strips should be pressed very firmly as the quality of the shell depends on this. If the pressure against the fingers, in rubbing out the paste, makes them sore, a piece of wood about 3" long and 1½" wide, rounded and slightly curved on the edge, may be used as a sort of squeezer. If the work has been well done, the case should be as firm as wood when dried. To assist in removing the wet shell case from the mold, first place in the bottom of it two strips of cloth at right angles with the ends protruding over the sides, long enough to permit pulling the case out by them when it is completed.

When the halves have been evenly trimmed place two together so as to form a sphere and secure joint with a strip of canvas smeared with glue. Then put on one or two more layers of paper. After again drying, bore hole for fuse through one end or better still bore hole through one half, from inside, with a wood bit, before joining the halves.

In addition to these methods very good shells can be easily and quickly made where hollow balls of zinc, tin or wood can be obtained. The wood half balls need only to be well glued together and they are ready for use. Those of zinc and tin require to be papered just as directed for shell making with round mold except that entire ball is papered until it is about ¼" thick for 6" shell and ½" for 10" shells. Others in proportion.

The cases for cylindrical or canister shells need no detailed description as they are made just like any other heavy case. A former of the required size is procured and the case rolled thereon just as for a mine, of strawboard or other paper. When thoroughly dry the wooden heads or plugs are fitted, nailed in with 1" iron brads, or well glued if made with a flange and carefully sealed all around with several thicknesses of good manilla paper.

DRYING CASES.

For all cases more than 6" long, racks are most convienent for drying them. These are made of strips of ⅞" x 2" cypress or other light wood, suitable for supporting them. The longer the cases, the farther apart the strips should be. When filled with cases they should be moved to a well ventilated room or covered platform. If placed in the sun they will be badly warped when dry. (Fig. 3) Center and end strips are ⅞" x 3".

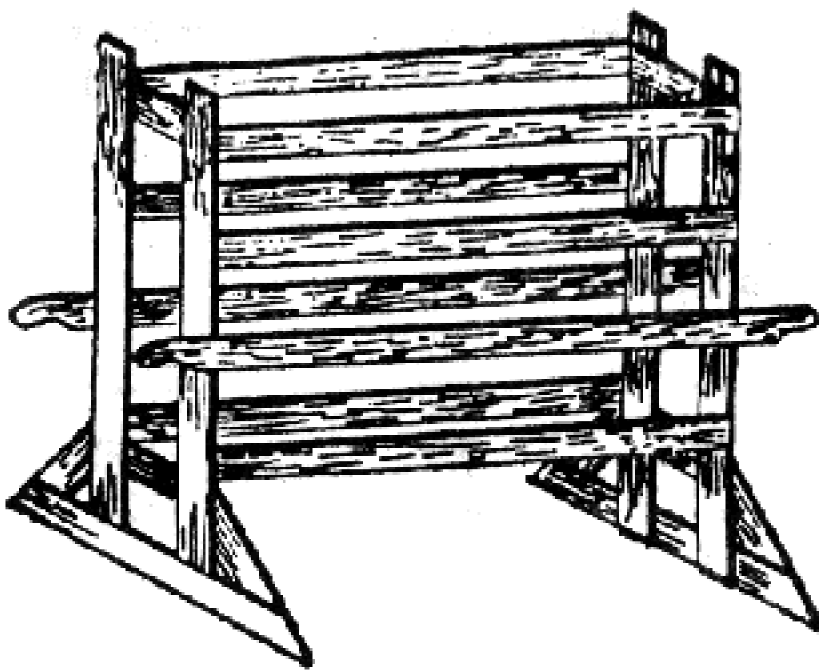


Fig. 3.

Small cases may be thrown into sieves 2 feet wide by 4 feet long, made of 1" material, 4" deep and the bottoms covered with galvanized hardware cloth of ½" mesh.

When cases are stored away care should be taken to protect them from roaches and mice as these are attracted by the paste.

FORMERS.

All paper cases are rolled on formers of one kind or another. For rockets, gerbs etc. these may consist of hard wood sticks but better formers are made of light brass tubing with an outside diameter equal to the inside diameter of the case desired. They should be one to two inches longer than the intended case and fitted with wooden handles to enable them to be easily removed when case is rolled. (Fig. 4)

Fig. 4

Rocket case Former

Mines etc. are rolled on wooden formers, the ends of which are turned down to convienent size to fit the hand. Roman candles are rolled on rods of machine ſteel while match pipes and pin wheels are rolled on thin brass or ſteel rods. Lances, on small brass tubing.

PASTE.

Without this simple article, I doubt if any great amount of modern fireworks could be produced, as it is in almoſt conſtant demand in every department of the factory.

Ready made paſte is now so easily and cheaply obtained that few persons care to bother about making it but for those not so fortunately situated the following is a ſtandard method:

> Mix 4 ozs. wheat flour with 8 ozs. water and ¼ oz. powd. alum, rubbing until free of lumps. Pour this slowly and with conſtant ſtirring into:
>
> 16 ozs. boiling water to which has been added,
> 5 drops carbolic acid,
> 5 drops oil of cloves,
> 2 grains corrosive sublimate.
>
> When cold it should be ready for use.

Another method which I am about to describe, I think, not only the beſt and simpleſt but requires nothing for preserving and if properly made, will keep for a month in winter. The process consiſts mainly in allowing the batter to sour before cooking; and cooking by adding boiling water inſtead of placing directly on the fire where it is likely to get lumpy or overcooked. The following details are for making paſte in lots of three or four buckets per day.

Procure two deep wooden tubs of about 20 gallons capacity. Buy a barrel of the cheapeſt grade of flour you can get. Samples or sour and wormy flour will do if it is not adulterated. Put 2 or 3 bucketfuls of flour into one of the tubs and add water, ſtirring meanwhile with a paddle until well mixed and about as thick as is convienent to handle. It does not matter if it is lumpy as these all come out in the souring. When the tub has been filled not more than one third full allow it to reſt in a warm place (about 90°F) for two or three days by which time fermentation will have set in. When the fermentation is complete the flour will have settled as a heavy batter in the bottom of the tub with a sour brownish liquid over it. Pour this off and fill several buckets about one third full of this batter. Now have a water boiler of about ten gallons capacity with faucet in bottom, on a gasoline ſtove or furnace and when this is filled with boiling water place one of the buckets of batter under the faucet. Open it and while the water is running in ſtir it briskly. The contents of the bucket will at firſt become as thin as milk but as it begins to fill it will gradually thicken until it can hardly be ſtirred if all the details have been correctly followed, and a bucket of clear, clean and very ſticky paſte, free from all lumps will be the result. The other tub may be used alternately with the firſt for souring batter while that in the firſt is being used for paſte making. This paſte, having been soured before cooking cannot sour again and will not become watery.

Glue and dextrine are sometimes added to make paſte bind better and alum, blueſtone, salicylic acid etc. to preserve it but these are all unnecessary if made as above.

CRIMPING.

Sometimes gerbs, etc. are choked or crimped to reduce the opening, in place of using clay. This is done by taking a turn of ſtrong ſtring or piano wire around the case while ſtill wet, about ¼" from the end and drawing tightly while turning the case slightly so as to make a neat job. One end of the ſtring should be tied to a wall or some unyielding object while the other is passed around the body (a) (Fig. 5). A nipple with a short point slightly smaller than the desired opening to be left in the end of the case, should be inserted about ½" before drawing the ſtring so that the end of the case will

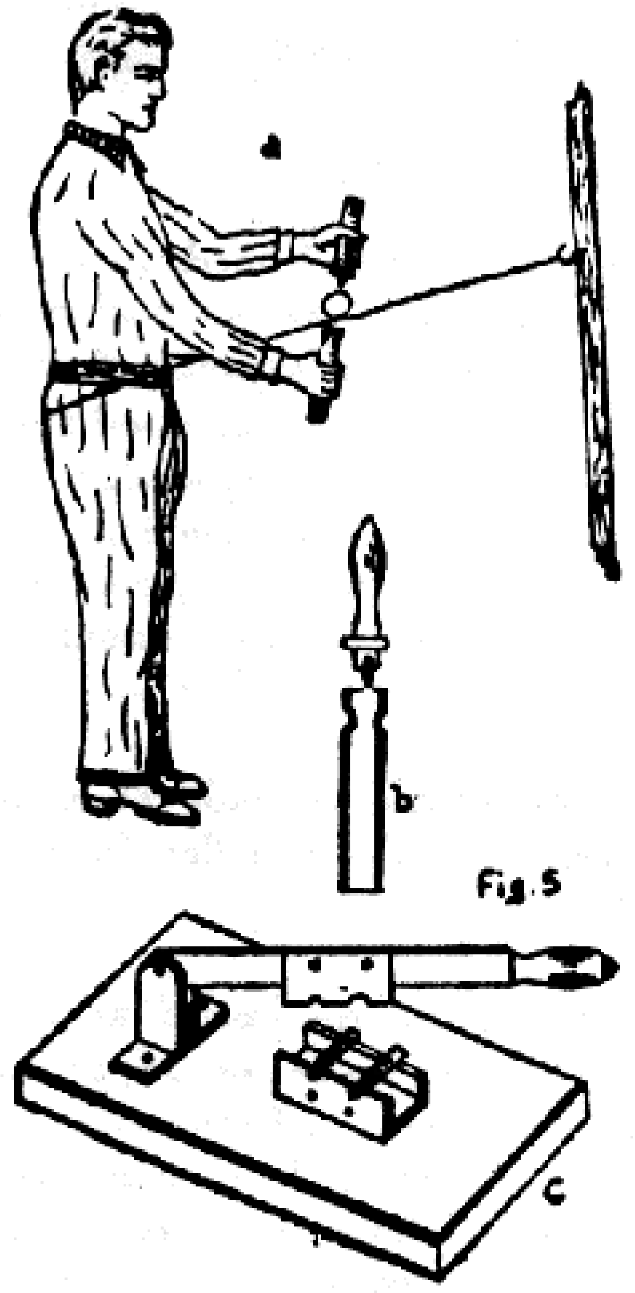


Fig. 5

be kept open and crimping neatly done (b). A mechanical device made by a Cincinnati machine works does the work very neatly and much quicker than the string process, (c) (Fig. 5).

RAMMING.

As this operation will be described in detail under each of the articles to be rammed as we come to them, only a few general directions will be given. All ramming should be done in small sheds as far removed from the balance of the factory as practicable and with one side open toward which the operator should always have his back while at work. A stout wood block, either resting on the ground or over a foundation should be used for ramming on. For heavy ramming the best mallets are those made of raw-hide. These are round and range in weight from ½ lb. to 10 lbs. About 2 lbs. is a good weight for the average work. (Fig. 6).

Fig. 6

Ramming tools should be made of brass or gun-metal also the nipples, while the spindles for rockets must be made of steel.

Scoops for taking up the desired amount of composition at a time, can be made of tin or any light metal and should be provided in different sizes from about ½" in diameter and 1" long to 1" in diameter and 3" long, with about six intermediate sizes as some compositions work better when rammed in small quantities than others with the same caliber of cases.

RAMMING with ROD and FUNNEL

For all small work such as serpents, saucissons etc. make a funnel about 4" high, 3 inch diameter on top and 5/16" at the bottom, without a spout, (Fig. 7) (a).

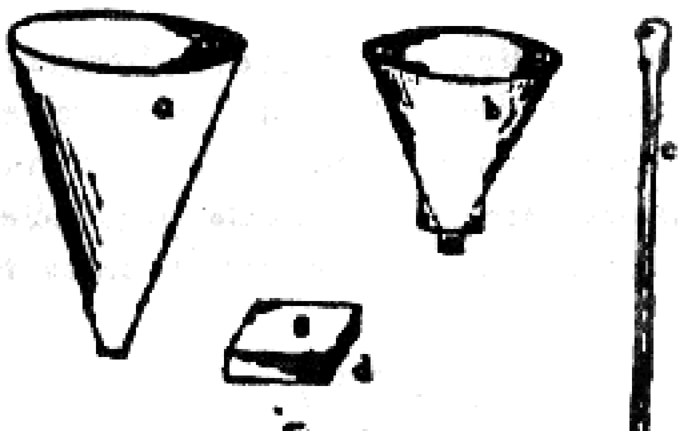


Fig. 7

Procure a rod ¼" diameter and 12" to 18" long according to work to be done. A wooden knob may be fastened to top of same for convienence in ramming (c). In use, a case is slipped on a nipple (d). The funnel, half full of composition has its small end inserted in top of case and with the rod moved up and down, striking the bottom firmly each time, the composition becomes rammed with sufficient solidity. When case has been rammed to within ½" of top, funnel is removed and a charge of clay is added to stop end, by striking clay a few blows with a light mallet and suitable drift or rammer. The arrangement for lances is somewhat lighter. The funnel (b) is very efficient. It is 2½" diameter on top and 2½" high with a ¾" shoulder on bottom and a spout ¼" outside diameter projecting from bottom for ¼". This, when removed from lance leaves just the proper amount of case empty for priming.

MATCHING.

This is the term used to designate that function of pyrotechny which consists of bringing fire to the various parts of devices as they are burned. In most of the individual articles a short piece of match is twisted in the nosing of the wrapper or fastened otherwise. In set pieces this operation takes on an importance second to none in the art.

Starting at a leader at which a set piece is lighted and which must be long enough to reach from the device when erected, to a convienent distance from the ground so the operator can reach it, the match must lead to every part of the piece.

The matching of lance work is fully described under that heading. In the case of set pieces consisting of gerbs, wheels etc. the gerb is first primed by smearing a little priming on inside of choked end of case. A nosing is put on, consisting of 2 or 3 turns of stout paper rolled around end of case so as to project 2 inches beyond end. About half an inch of the piping is removed from a length of quickmatch. This is bent back, inserted into the nosing and secured by tying tightly with two half hitches. The match is now brought over to the next gerb and bent at right angles over it. At 2 inches from this point it is bent back again onto itself and at point of first bend, again at right angles so as to lead to the next gerb. (Fig. 8). At the bottom of this bend the piping is cut off, bearing match, with a sharp knife, and this portion pushed into nosing of second gerb and secured by tying as before. See (Fig. 8). Candles, wheel cases etc. are treated in the same manner.

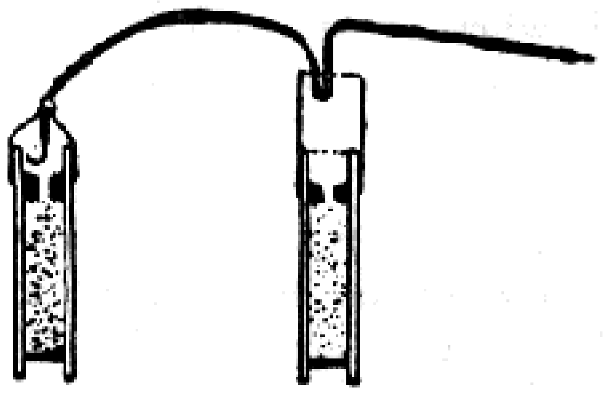


Fig. 8

If a gerb has been properly primed it is not necessary for the match to enter choke as fire will reach it from priming.

It is a good plan to have the leader from which a piece of fireworks is ignited, to run to each section of same, irrespective of the fact that said sections are already connected to one another in the process of matching it, as sometimes a length of match will go out in the center of the pipe, owing to some defect not observed in making it. It is therefore advisable to have the match joined wherever it crosses, as for instance, on top of a lance guarding as much as possible against all chance for one or the other section to fail.

If it is desired to have one part of a piece to burn after the other has been burning a-while, as when candles or gerbs are used in connection with lance work, these gerbs etc. are matched to a separate leader which may be fired by hand after the lances are half consumed, or they may be connected to several lances about half way down so that when they have burned to this point the balance will be lighted automatically. This is done because, lances burning so much longer than candles or gerbs, if all are fired at once, the gerbs etc. would be finished before the lances were well under way, while it is best for the finest effect to come at the end.

PRIMING.

In order to insure lighting, especially in exhibition work, all gerbs, wheel cases, lances etc. are primed which consists of smearing a little moist gunpowder about the mouth of the case. Priming is made by adding water to grain powder in a suitable receptacle until the powder becomes pasty. A little alcohol and dextrine can be advantageously added.

FINISHING.

In factories, where stock or shelf goods are made this is quite an important department. All kinds of fireworks are covered with some kind of colored paper and often stripes and borders are added. Candles, rockets, serpents, small mines and triangles are covered with different colored poster. Flower Pots are usually covered with calico paper while fancy rockets, large mines saucissons, floral shells and fountains are covered with glazed paper, stripes being added where desired. The size of cuts as given here are for use with candles and rockets of the size shown in this work. They are usually 2" longer than the article to be papered if it has to be matched at one end and tucked in at the other; 1" longer where matching only is done and the same length where only the case is covered as in mines etc.

1	oz.	Sky	Rockets			3" x 5"
2	"	"	"			3" x 6"
3	"	"	"			4" x 6½"
4	"	"	"	with	cone	4" x 6½"
6	"	"	"	"	"	5" x 7"
8	"	"	"	"	"	6" x 8½"
1	lb.	"	"	"	"	6" x 9½"
2	"	"	"	"	"	7" x 10½"

1	ball	Roman	Candles	2" x 6"
2	"	"	"	2" x 7"
3	"	"	"	3" x 8"
4	"	"	"	3" x 10"
6	"	"	"	4" x 14½"
8	"	"	"	4" x 17"
10	"	"	"	5" x 19"
12	"	"	"	5" x 21"
15	"	"	"	6" x 24"
20	"	"	"	6" x 28"
25	"	"	"	6" x 34"
30	"	"	"	6" x 38"

WRAPPING.

To make a good neat, tight and strong bundle is about as important and I may say difficult to learn as any other part of the fireworks business.

Roman Candles from 1 to 4 ball are packed 3 dozen in a bundle. From 6 ball up, 1 dozen in a package. The packages of 1 dozen are made in two forms, viz: four sided and six sided, (Fig: 9) (b) and (a) respectively.

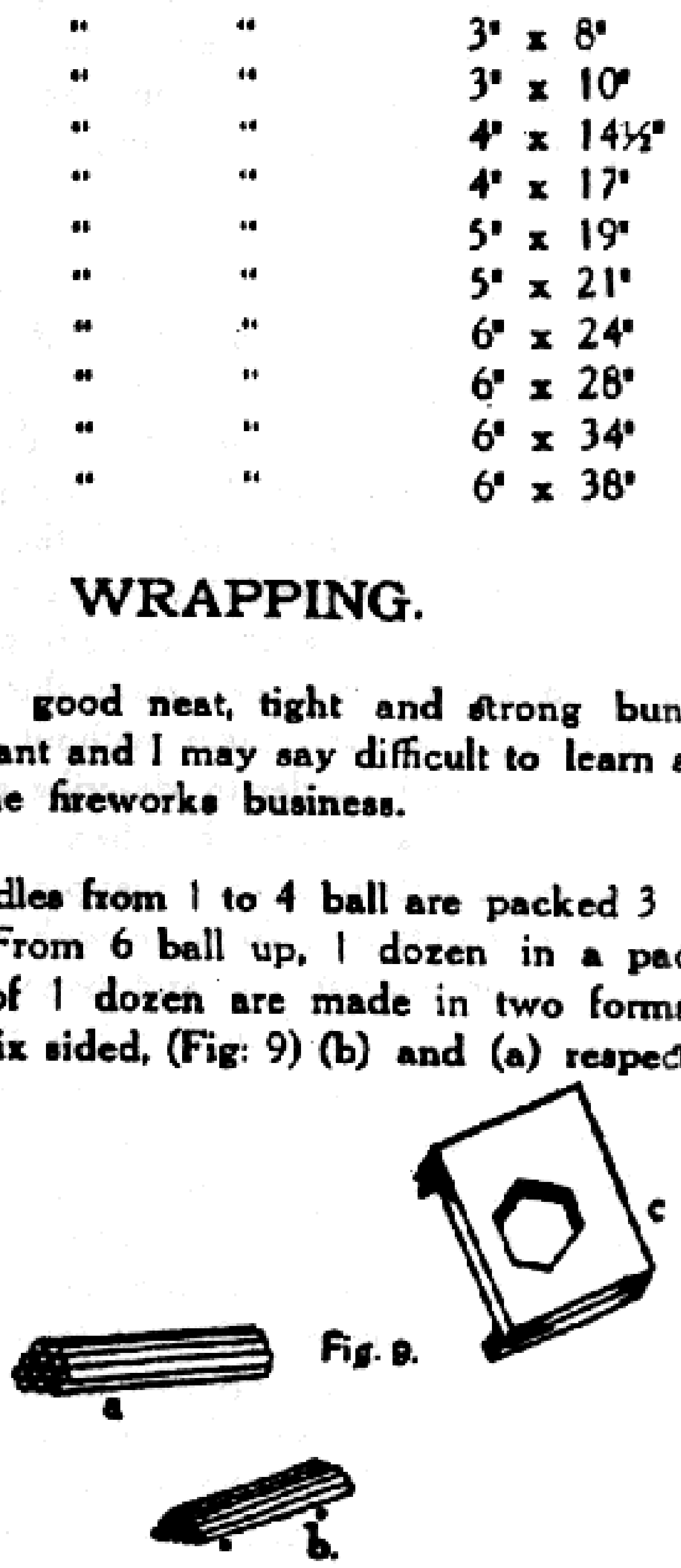


Fig. 9.

To make the four sided package of 1 dozen 8 ball candles lay 5 on the bench in front of you so the candles run paralel with the bench. Mark the space they cover and fit into top of bench four wood pins about one inch of which project above, two on each long side of the space occupied by the 5 candles, so same may be easily laid between them. See dots, (Fig. 9), (b). Now cut a sheet of manilla paper 19" long and 14" wide and lay this between the pins just as the candles laid before, and replace the five candles, now on top of the paper between the pins. On top of these five place four more and on top of them three. This makes twelve. Draw the paper tightly over them and fold it like a druggist makes a bundle. Now close the ends as follows: with two fingers press the top of the folded paper over the end of three top candles; then, holding same down with both thumbs, fold in the two sides of package with the first and second fingers of each hand at the same time; then holding these folds with the left hand, lift the opposite end of the bundle with the right which will cause the bottom to fold itself over the other folds. Now, with a brush dipped in thick paste give the end a daub on the last fold and while the bundle is still standing on this end fold the top end the same way. Before folding the last fold give it a daub of paste as you did the other end. Lean against the wall and place a paper weight or tile on top of end to hold it in place until dry. After a quantity are packed like this and dried the labels are affixed.

To make the six sided bundle a person must first learn to form the candles in the hand. Count out one dozen candles and encircle the bunch at one end with both hands. Now work them about (this is hard to describe on paper) until they form a triangular bunch (a) with three candles on each side of the triangle. When this has been accomplished, lay them on the wrapping sheet (cut as described above, though preferably wider) holding them lightly so they retain the triangular form. To get the paper around them without having them to fall in a heap is still harder to describe and equally hard to master though easy enough when learned. Once the bundle has been gotten to the wrapping sheet one hand is sufficient to maintain its form so with the other lift the side of the sheet nearest you and bend it partly around the package so you can hold it while the other hand is released long enough to enable it to take the paper on that side. Straighten and flatten it well on over the candles and begin rolling up the bundle until the other edge of the paper is reached. Paste this edge and lap it on the bundle and you are ready for the corners. If the bundle has been properly made, when it lays on one of the faces of the triangle, the top row must be composed of 2 candles; the second row, 3 the third row 4 and the bottom row 3. Now bend the paper down from the top first, then bend in the two upper sides, then the two lower sides and finally, by lifting the bundle, from opposite end, the bottom folds over all the others. A little paste secures it as described above.

The bundles of smaller candles are formed in a wooden former, hollowed out to the size of a bundle of 3 dozen (c) and when it is packed with the required number they are secured with a string perparatory to wrapping.

Short stick sky rockets are nearly always packed in paper boxes. Long sticks are packed as follows: Cut some pieces of #18 iron wire 6 inches long. Then take half or a dozen rockets with the heads all even and work them in the hands until they form as square a bundle as possible and bend one of the pieces of wire around the sticks just below the matches. This should be done with one hand while the other holds the bundle in shape. Now pass another wire around the sticks about a foot from the bottom. Cut some pieces of strawboard as wide as the bundle of rockets on the wide sides and long enough to go completely over the heads and down the other side nearly to the matches. Cut some wrapping paper six inches wider than the rocket head bunch and long enough to go twice around it. Paste the far edge for about one inch and lay the bundle of rockets with the strawboard around it, on the sheet and wrap it up as tightly as possible. Fold in the upper end; secure with a little paste and set aside, heads downward, to dry. Later, the other end may be gathered in and secured with another piece of wire.

Wheels, tourbillions etc. are made into most any kind of a package desired, while mines, fountains etc. are given one or two turns of paper over the finishing to keep them clean.

Serpents, flower pots and torches are packed like roman candles. Blue lights, the same. Fancy rockets are packed heads and sticks separately, the heads in boxes and the sticks loose.

WIRING.

For most purposes annealed iron wire from 18 guage to 20 guage is the most servicable. The easiest and quickest way to use it for wiring rockets, triangles etc. is to cut it in lengths of from 4" to 6" according to the size of the work to be done. A large quantity can be cut at once by using a bench shear and cutting several hundred at one time. Rockets can be quite securely fastened with one wire if a GUM BOARD (Fig. 10) is used. Else two wires are necessary. A gum board is made by taking a piece of ½" board 6" long and nailing pieces of rocket stick around it on three sides on top and one side on the bottom. Put into this about 1 oz. of dextrine mixed with water to the consistency of jelly and it is ready to commence wiring.

Fig. 10

Put a pile of rockets and wire to your left and a bundle of sticks and the gum board to your right. Rub one side of the end of a stick against the bottom of the gum board so a little gum will adhere to it. Lay it with the gummed side against the rocket about three quarters of the way to the cone. Hold it in this way in the left hand and with the right, bend a wire around it about the middle giving one turn on the side of stick. Now, with a pair of nippers give about three more turns cutting the wire with the last turn. If no gum is used two wires are necessary.

TYING.

In doing exhibition work string plays a very important part and the best and most convienent knot for all purposes is the sailors two half hitches. (Fig. 11).

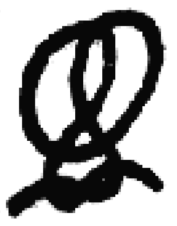


Fig. 11

This is somewhat difficult for most persons to learn. The best way is to practice on a stick. Pass string under stick bringing free end over left of loop; bring it over same again passing end again to left of second loop but between second and first. An ordinary tie of the free ends now secures it permanently. This knot will be found invaluable in matching.

LABELING.

This very easy operation may be still further simplified if done in the right way. Take a board about a foot square. Smear it well on top with thin paste and lay a label on it, face down. Cover this well with paste and place another label on top of it repeating the pasting and putting down of labels until several dozen are on the board. This will soften them so that when taken up and pressed with the fingers or the paste brush against the bundle to be labeled they will adhere firmly and lay flat.

DESIGNING.

When it is desired to produce in fireworks a portrait, a picture of a building, monument etc. or a line of lettering this is first drawn on the floor with a piece of chalk fixed into the end of a stick so that the designer may walk about sketching his picture from the miniature plan as he goes along. The floor is first laid off with a chalk line into squares one foot each way and in multiples of 50 square feet five feet wide and 10 feet long. For instance, if a picture 10 feet high and 20 feet long is desired it is composed of 4 sections 5' x 10' or two high and two wide.

The sketch is now taken and marked off with rule and dividers into 200 equal squares, 10 high and 20 wide corresponding to the full sized squares on the floor. These are numbered along the edge of sketch on top and on one side. The squares on the floor are numbered in the same way. With the chalk now draw into each square on the floor, the same lines as appear in corresponding square of sketch. When this is done, an exact reproduction of small picture will be ready to be placed on frames.

For lettering or lines of wording this is not necessary as design can usually be drawn directly onto the floor with free hand, of the desired size and without enlargement.

PART III

ARTICLES OF MANUFACTURE.

MATCH.

(Quick Match)

This is used for conveying fire to the cumbustible portion of pyrotechnical devices and is distinguished from FUSE by the fact that its effect is almost instantaneous while fuse burns at a comparatively very slow and exact rate. It consists of cotton wicking impregnated with gunpowder and covered with a loose paper piping. As almost every piece of fireworks requires, match for lighing it and lance work and exhibition pieces in general are absolutely dependent on good match for their successful operation it is essential to make this very necessary article as nearly perfect as possible. There are several ways of making match which will be classified as the "French System" and the "English System" and candle and rocket match.

French System

Secure two pieces of 1" x 3" lumber and into one edge of each drive a number of 8d nails for half their length, about one inch apart. Set these pieces up horizontally, with the nail edges uppermost, about 3 feet above the ground, one at each end of a dry shed some 30 feet long. Wicking or cotton cord of the proper thickness can be secured already in balls, as desired. Now get some cotton cord or wicking not less than 24 mesh and fasten the end to the nail nearest the wall, on one of the above pieces of 1" x 3". With the ball of cord walk to the other end of the shed and, drawing it rather tightly, fasten it to the corresponding nail in the other strip of 1" x 3" by taking a few turns around the nail. Leave the ball temporarily at this end of shed, in a light box to keep it clean.

In an agate pan mix 3 lbs. rifle powder thoroughly with 4 ozs. dextrine and add water, stirring with the fingers until all the grains are wet. Allow to stand a few minutes until a small lump pressed between the fingers feels perfectly smooth and contains no more grains. Stir in some more water and a little alcohol until the mixture is about the consistency of mush.

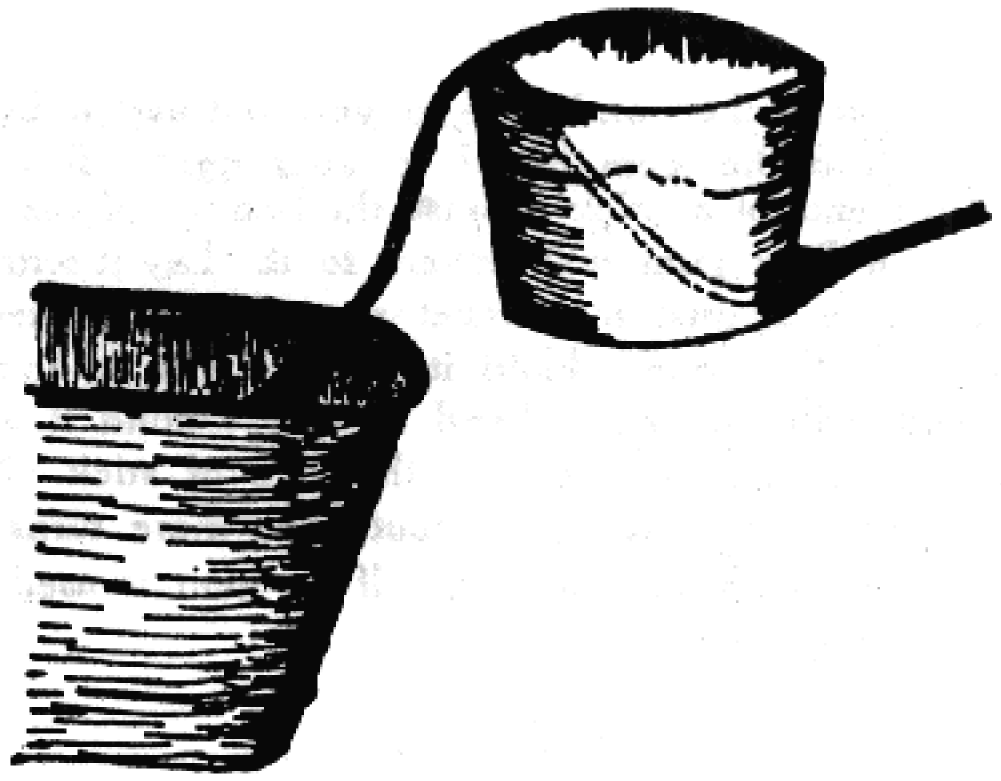
Holding the pan in the left hand, under the first length of cord take up a handful of the powder mixture and work it well into the cotton while holding the pan so as to catch the drippings, and walk backwards to other end of shed. When this is reached go back to the begining of the strand, take some of the powder in the right hand, pass the cord over the first joint of the first finger, place thumb on top of it and again walk backwards toward other end of shed but without working any more powder into the cord, simply allowing it to run through the finger and thumb for the purpose of rubbing off rough uneven places and leaving a smooth well finished surface.

Now take up the ball of cord again and, passing it around the third or fourth nail to the right, stretch a second length to the point of begining, fastening it here also several nails away from the first strand. This is for the purpose of not touching the finished strand while working the powder into the second one. Proceed as with first length and when finished move it to second nail, stretching it tightly into place. Repeat with the following strand until all the powder is used up.

If the weather is dry match will be ready for piping in a day or two. In dry climates gum arabic makes a better match than dextrine but where there is much moisture in the air dextrine is safer. When the match is dry and stiff it may be cut down and the pipes threaded on. Match pipes are made of 20 lb. manilla or kraft paper 24" x 36", cut into strips 4" wide and 36" long, rolled on a ¼" steel rod, only the edge of the sheet being pasted for about one inch. When piping match crease or gather the end of first pipe when in place so next pipe may be slipped over it for about 1 inch.

A simple and clean method of making perfect exhibition match, and one, which to the best of the authors knowledge is original, is as follows:

Make a cup of brass, about 3" diameter, at top, 2½" at bottom and 2¼" high as shown in accompanying sketch.



At its bottom attach a spout pointing upward and terminating in an opening ⅛" diameter. A small dish pan, a 2 quart pudding pan and a match frame 4' x 6' complete the requirements of apparatus. Then prepare the following mixtures;

No. 1	
Dextrine	3 ozs.
Gunpowder	2 lbs.
Water	2 pts.
Alcohol	4 ozs.

No. 2	
Dextrine	1½ ozs.
Gunpowder	1 lb.
Water	12 ozs.

Into the dish pan place mixture No. 1, mixing the gunpowder thoroughly with the dextrine before adding water. When powder has completely melted add alcohol, and stir well. Unwind into this about 2 lbs. of good cotton twine of not less than 24 mesh, and with a stick press it well into the powder mixture. Into the pudding pan place mixture No. 2 proceeding as for No. 1. This however, should be thicker; (about like soft putty).

Now take the end of the cord and pass it through the spout of brass can, from the inside; fill the cup with mixture No. 2 and pull through spout enough cord so end may be attached to match frame. Hold the cup in the left hand and revolve the frame with the right, placing dishpan so cord will feed out, over notch in back of top rim of cup and through powder mixture into frame separating each strand by about ¾". If spout of cup fits cord snugly a perfectly round, smooth match will result and if surgeons rubber gloves are worn the hands will not be soiled. Be sure to keep the small cup always full.

English System

Make a light frame of wood like the frame of a looking glass (Fig. 12), six feet long and four feet wide

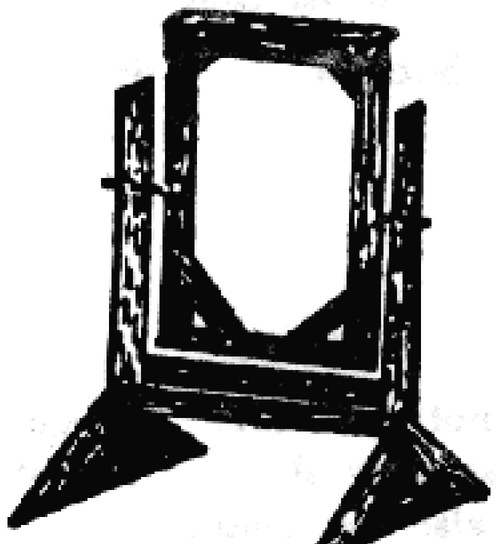


Fig.12.

and hang it in an upright stand so that it can revolve just like the mirror in a dresser. Then get a quantity of cotton wicking, 24 mesh and unwind it into a thin pan about a foot in diameter and six inches deep. In another similar pan put 2½ lbs. rifle powder mixed with 2½ ozs. dextrine and cover it with 2½ pints water, stirring occasionally until powder is melted; then add 2½ ozs. alcohol and mix well. Pour this over the lamp wicking in the first pan taking care to leave the end of wick hanging over edge of pan so it can be easily found. Begining with this end now run all the wicking into the empty pan, taking care that every part of it is well soaked with the wet powder, a little of which should remain after the cotton is passed for the first time and this may now be poured over the pile of wet wick, pressing or kneading same so as to thoroughly soak every part, when it can be returned to the first pan as before. It is now ready for the frame. Tie the end of wick to one side of end of frame and while someone turns it slowly feed match into it with the strands about ¼" apart. When all of it is on the frame remove from the stand to a part of the floor covered by large sheets of paper and support it over these on four blocks about 3" high, one at each corner of frame. Now, take a small sieve of meal powder and dust it carefully over so as to cover it evenly with a layer of powder. The frame of match may now be placed in the sun or elsewhere to dry. Match made by this process is all of one length, viz: 2 yards, and is very round in appearance. It burns fiercely but will not stand as severe usage as that previously described. It also takes longer to make.

Match piping serves the double purpose of protecting the match from injury and making it burn infinitely faster. A piece 20 feet long will flash from one end to the other in less than a second.

ROCKET and CANDLE MATCH.

Match made by either of the two previous methods is too expensive for use with the cheap grade of stock fireworks on the market so a simpler method has been devised for this purpose. It is essentially like the last described process.

Into a small tub put a gallon of starch, well boiled, and stir into it about 15 lbs. of a thoroughly mixed composition made of

Saltpeter	16
Fine charcoal	5
Sulphur	2½

Soak in this, cotton wick of about 5 strands until nearly all the composition is absorbed but about one half inch which should still cover the cotton in the tub. Work it in well and run it on a frame as directed in preceeding description but the frame may be smaller for convienence of handling by one person, as long lengths are not required. Neither does it need to be dusted with meal powder. If well made, however, it will burn freely and serve its purpose completely. When dry it is tied in bunches, 1 to 2 inches in diameter and cut into the desired lengths with a tobacco cutter or large sharp knife.

FUSE.

(Blasting)

This is used in fireworks making, in the production of cannon crackers and to a lesser degree in small bombshells. It consists essentially of a cotton pipe containing meal powder and burns at a rate of approximately 1 inch in 3 seconds. It can be had in sizes varying from ½" to ¼" in diameter and from the cheapest painted cotton kind to one heavily coated with gutta percha for under-water work.

It is made by a very ingenious machine which weaves a cotton fabric around a small tube. As this tube is withdrawn its place is taken by the meal powder which is forced in through the opening in the tube. The largest factories are in Simmsboro, Conn.

TABLEAU FIRE.

(In testing colors the pyrotechnist should not look directly at the burning mixture but should have his back turned to it while someone else lights it. He should then turn quickly around for a moment and look at the light and then turn away again. By looking directly at the burning color the optic nerve seems to be temporarily affected so that an accurate appraisal of the color cannot be made. It is also well to view the color from a distance of about 100 feet to judge it accurately.)

This is about the simplest form of fireworks at present in use. It is made by mixing thoroughly the necessary ingredients to produce the desired color and heaping it on an iron plate or board, in a pile, so it may be easily lighted. Or it may be put up in tin cans for the trade. Good tableau fire should burn brightly without sputtering and smoke as little as possible. It should take fire easily but never be liable to spontaneous combustion. Lithographed cans may be used as containers, designating by their color the color of the fire they contain and with firing directions printed on them. A small piece of match placed in each can facilitates lighting it.

WHITE FIRE.

Saltpeter	3	12	8	7
Sulphur	1	2	2	2
Metalic antimony	1			
Antimony sulphide	1	1		
Realgar			1	1½

BLUE FIRE.

Potassium perchlorate				24
Potassium chlorate	6	16	8	
Paris green	4		6	
Shellac			½	
Stearine	1		1	2
Barium nitrate	4		7	
Calomel		12	1	
Sal ammoniac	1			
Copper ammon. chloride		4		6
Asphaltum				1
Lactose		6		

In the above color it should be bourn in mind that paris green is very poisonous and a handkerchief should be tied over the nose if it has to be handled much.

RED FIRE.

Strontium nitrate	80	10	16	14
Potassium chlorate	20	4	8	4
Shellac			3	
Red or Kauri gum	12	3		
Asphaltum				3
Charcoal		1		
Dextrine	1			
Fine saw dust	12			
Rosin		1		
Lampblack	1			

If it is desired to make tableau fires more bulky one or two parts of fine sawdust may be added to any of the above recipies without materially affecting the color. If the sawdust will not pass freely through the sieve it may be added after the other ingredients are sifted and mixed and rubbed in with the hands.

PINK FIRE.

A fire somewhat cheaper than the above but inferior in color may be made as follows:

Nitrate of Strontia	48	16	18
Saltpeter	12	4	7
Sulphur	5	2	2
Charcoal	4	1	½
Red gum		3	2
Dextrine			½

This should not cost over 7 cents per pound while the other formulas cost about 9½ cents per pound. A pink light may also be made by substituting lime or chalk for strontia but more chlorate of potash is required and the smoke is greater.

YELLOW FIRE.

Nitrate of baryta	36
Oxalate of soda	6
Sulphur	3
Red gum	5

GREEN FIRE.

Nitrate of baryta	8	9	4
Chlorate of potash	4	3	2
Shellac		1	1½
Red gum	2		
Dextrine		1/16	
Fine saw dust		½	
Sal ammoniac	1		

I have never found anything better or as good as this, therefore give only the one recipe.

SMOKELESS TABLEAU FIRE.

For theatrical or indoor use colored fires are very objectionable on account of the choking smoke they give off. The following mixings give a fire producing very little smoke which quickly dissipates after fire is burned.

RED.

Nitrate of strontia	8
Picric acid	5
Charcoal	2
Shellac	1

GREEN.

Nitrate of baryta	4
Picric acid	2
Charcoal	1

Disolve picric acid in boiling water; add strontia or baryta; stir until cold and dry on filter or piece of cloth.

It should be observed that in all mixings, the formulas cannot be considered absolute as the purity and general characteristics of chemicals differ so much that all mixings must be tested and regulated to the existing conditions of materials, climate etc. If tableau fire burns too slowly more potass; or coal should be added; if too fast, more strontia, baryta etc. In rocket, candle or gerb compositions, saltpeter or meal powder will increase the combustion while coal and sulphur will retard it.

TORCHES.

These may be clasified according to the purpose for which they are intended. Military torches have but one requirement which is that they produce the maximum illumination of the deepest hue of color desired. As these are fully described in special works issued by the government and really form no part of commercial pyrotechnics it will be unnecessary to devote further space to them here. Railway torches or fusees, on the other hand, are the cheapest form of pink light, as anything capable of attracting the attention of the engineer is all that is required. They are usually ¾" diameter and 8" to 12" long exclusive of the handle and burn from 5 to 20 minutes. The following compositions are adequate:

RAILWAY FUSEES

Potassium perchlorate				2½
Strontium nitrate	48	18	16	18
Saltpeter	12	7	4	
Sulphur	5	2	5	2¼
Fine charcoal	4	½	1	
Red gum	10	2		
Dextrine		½		
Sawdust				

Potassium perchlorate	4
Strontium nitrate	40
Sulphur	5
Red gum	2
Vaseline	1

moisten with Kerosene before ramming

Fusees are provided with a slip cap which is used for igniting them. The end of the torch is capped with paper onto which is painted a mixture of

Potass; chlorate	6
Antimony sulfid	2
Glue	1

while the end of the cap is similarly painted with a paste of:

Black oxid of manganese	8
Amorphous phosphorus.	10
Glue	3

When the cap is pulled off and struck against the end of the fusee it takes fire like a safty match. With some compositions it is necessary to have a little starting fire at top of torch just under the capping or priming under the cap which will suffice to cause easy ignition. (Fig. 13)

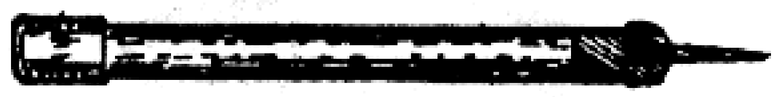


Fig.13.

PARADE TORCHES

Parade torches for campaign purposes, where a cheap grade of fire suffices and where competition urges the manufacturers to produce the largest article at the smallest price, one of the methods is to add 50% of fine sawdust to the mixing. This does not greatly affect the burning of the torch and makes it look twice as large at practically no extra cost. The following is a good formula:

RED.

Nitrate strontia,	30
Potass; chlorate	8
Red gum	7

Saw-dust may be added ad libitum. The torches are usually ¾" diameter and 12" long and should burn, with the above mixing, 8 to 10 minutes.

RAMMING CAMPAIGN TORCHES.

A very cheap method of ramming these torches is to moisten the composition with dilute dextrine solution until it is damp enough to hold together when a handful is tightly squeezed. A dozen torch cases are tied in a bundle and pressed into a pile of damp composition on a slab. It is then moved to a clear. part of the slab and jolted firmly against it by lifting the bundle a few inches and jarring it downwards. More composition is shaken in from the top when the jarring is repeated and this continued until torches are full when they are set aside to dry. By this manner a dozen torches may be rammed in one minute. The handles may be attached by a strip of gummed paper 2 inches wide, half of which encircles the torch and the other, the end of the torch handle. The other end of torch is nosed and matched in the regular way, (Fig. 14).

Fig.14 Campaign torch.

A better way of ramming torches is as follows:

Tie the cases in bundles of 12. Place on ramming block and insert spout of funnel (Fig. 15), into one of them. Then pass a suitable rod through it until it rest on block also. Now, with a scoop, fill the funnel with composition and, steadying same with the left hand, grasp the rod firmly with the right and raising it about six inches, drive it with a firm stroke up and down as the composition runs into the case. Continue this operation until case is filled. When funnel is removed the space occupied by the spout will serve for inserting the handle which is done by applying to it a little gum or glue.

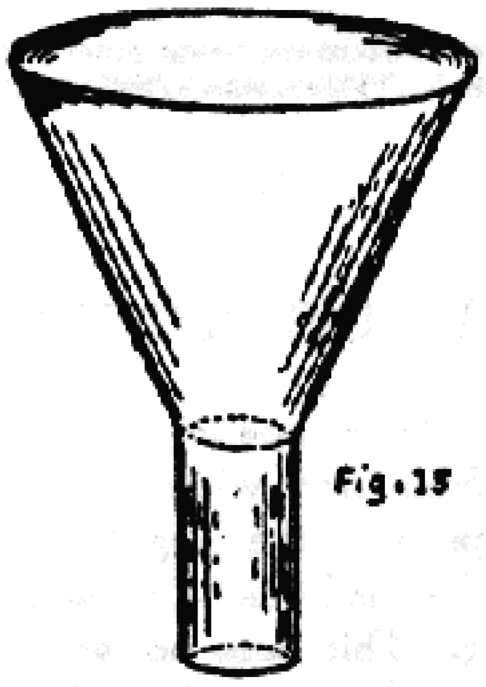


Fig. 15

TORCHES for CARNIVAL PARADES.

These present the most exacting requirements and the following formulas are the result of more than 30 years of experimenting during which some exceptional mixings have been developed as well as some most beautiful colors which, in modified form, may be used for box stars in shells etc.

Carnival Parade Torches must be of deep color, give maximum illumination, burn slowly and clean, not be prohibitive in cost and give off as little smoke as possible. They should burn not less than 15 minutes with a length of about 18" exclusive of handle and a diameter of ¾".

The standard formula of 40 years ago was: for

RED.

Nitrate strontia	16
Potass: chlorate	8
Shellac,	3

however, this burns somewhat fircely and is rather expensive. A better mixing is:

Nitrate strontia	14
Potass: chlorate	4
Ground asphaltum gum	3

or

Strontium nitrate	40
Potassium chlorate	8
Red gum,	7½

This will burn 17 minutes in an 18" torch. The latest formula, giving exceptional results is:

Strontium nitrate	9
Potassium perchlorate	2
Sulphur, ground	2
Red gum	1

This gives a fine color, burns clean and is inexpensive.

GREEN PARADE TORCHES

Barium chlorate			5
Barium nitrate	40	30	4
Potassium chlorate	11		
Potassium perchlorate		6	
*K. D. gum	6	2	
Sulphur, ground		3	
Sal ammoniac	1		
Shellac			1
Calomel			2

*K. D. and Red gum are supplied by New York dealers in pyrotechnical supplies.

BLUE PARADE TORCHES

Potassium perchlorate	5	24	24
Paris green	2		
Copper-ammonium sulphate		6	
Copper-ammonium chloride			6
Dextrine	1		
Calomel	1		
Sugar of milk		2	
Sulphur		9	
Stearine			2
Asphaltum			1

PURPLE PARADE TORCHES

Strontium nitrate	7
Potassium perchlorate	9
Black oxid of copper	6
Calomel	3
Sulphur	5

AMBER PARADE TORCHES

Strontium nitrate	36

Sodium oxalate	8
Shellac	5
Sulphur	3
Potassium perchlorate	10

The last two torches are exceptionally beautiful and have been used very effectively in canival parades. Great care must be observed in mixing compounds containing sodium oxalate, that all the ingredients are perfectly dry, and it is best in a damp climate, to mix only on a clear day, for the reason that the least moisture is liable to cause the oxalate to decompose forming sodium nitrate or chloride which is still more deliquescent than the oxalate and the work is soon so wet that it will not burn. Even when mixed in dry weather it should be protected from dampness by parafined wrappings or otherwise.

In cutting the paper for a 15 minute parade torch ¾" diameter and 18" long cut 35 to 40 lb. Kraft paper so it will roll with the grain 18" in length and across the grain 11¾". This will give four complete turns and cause more regular burning. Pasting the outer edge for 3 or 4 inches will be sufficient.

Capping and Matching Parade Torches.

A good method of doing this is as follows:

Cut some cotton cloth into pieces about 2 inches square. Cover them with paste and bend them securely over the tops of the torches as shown in sketch (Fig. 16a). When they have dried punch a hole about 1 inch deep through the cloth and into the top of torch, with an awl about ¼" diameter, into which insert the match. Then make up some thin priming of gunpowder, gum water and a little alcohol. Place this in a squirt oil can with a large opening in its spout and shaking frequently to prevent it from separating, press out a drop or two at the point where the match enters top of torch. If this is properly done it will secure the match in place and cause the torch to ignite freely.

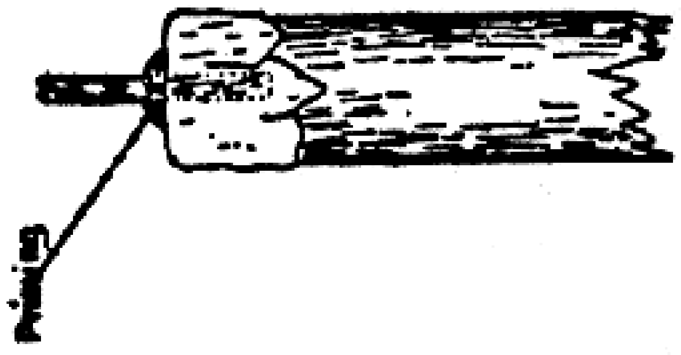


Fig. 16a.

ALUMINUM TORCHES.

This beautiful piece of pyrotechny was first introduced in parades by the author, with sensational results, about 35 years ago. A row of 12 men was placed at the head of the line of march and with these all burning aluminum torches simultaneously there was produced the effect of an oncoming avalanche of fire. For this torch a case ½" diameter and 16" long is used with a round wooden handle 6" long. They are rammed and matched much as other parade torches and a good formula is:

Potassium perchlorate	13
Fine aluminum powder	6
Flake aluminum	5
Dextrine or licopodium	1

A beautiful modification of this is the

RED and ALUMINUM TORCH.

These should be ¾" diameter 18" long and of the following composition

Strontium nitrate	35
Potassium perchlorate	7
Shellac	4
Coarse flake aluminum	4
Lycopodium	1

another formula is:

Strontium nitrate	13
Sulphur	3
Mixed aluminum	3

Before ramming, this formula should be moistened with a solution of 1 part shellac in 16 parts of alcohol and one part of this solution used to every 36 parts of composition. As this mixture is somewhat difficult to ignite it is necessary to scoop out a little from the top of torch and replace it with starting fire as shown in (Fig. 17).

Starting fire
Torch
Fig. 17

STARTING FIRE.

Saltpeter	6
Sulphur flower	4
Fine charcoal	1

An aluminum torch of heretofore unheard of brilliance and giving an illumination, in the 1 inch diameter size, of what is said to be 100,000 candle power is made as follows:

Barium nitrate	38
Mixed aluminum	9
Sulphur	2
Vaseline	1

Rub the vaseline into the barium nitrate; mix sulphur and aluminum separately; then mix with barium nitrate and vaseline. A ſtarting fire for this also is required, as follows:

Barium nitrate	4
Saltpeter	3
Sulphur	1
Shellac	1

PORT FIRES.

These are small torches ¾" diameter 12" long, used in exhibitions for lighting other pieces of fireworks. They are rammed with rod and funnel and a good mixing is:

Meal powder	1	
Sulphur	2	4
Saltpeter	5	5
Charcoal		1

Ship Lights and Distress Signals.

"BENGOLAS"

Another form of torch is the Bengola or Blue Light used moſtly by ships in signaling for pilots. They conſiſt of a ſtout paper case 1½" in diameter and 4" long, 3" of which is composition and ½" clay at bottom; the balance being the socket into which the handle is fitted, (Fig. 18). They should be rammed quite hard; the nosing should be of good ſtrong paper secured around the match with twine and the match should be piped where it passes through the nosing. The finished light should then be painted with melted parafine so as to protect it againſt the dampness of the sea air. This is an average formula:

Fig.18.

Saltpeter	12
Sulphur	2
Antimony sulfid	1

Diſtress signals are the same except that they burn red. The regulation Life Boat equipment conſiſts of 6 or 12 enclosed in a water tight copper can. The following formula is suitable:

Potass: chlorate	5
Strontium carbonate	1½
Shellac	1
Dextrine	½

TOY BLUE LIGHTS.

These are little lights ½" diameter and 6" long made by rolling a light case as for lances. Cut the paper 2" x 6", the 6" way running with the grain of the paper. One end should be closed as for lances. Bunch about 200 into a bundle with string, all the open ends being uppermoſt when the bundle is ſtood on end. Now make the following composition:

Saltpeter	5
Sulphur	2
Antimony sulfid	1

When thoroughly mixed place it on a large sheet of ſtrong paper previously spread on a firm table. Set the bundle of blue light cases alongside of the composition on the paper, with the open ends up and pour a handful of composition on top of them. Shake the bundle so as to make composition fall into the cases as much as possible and repeat several times. Now with both hands raise the bundle of partly filled lights and bring it down on the table with a good blow. Repeat this several times and then again the firſt operation of filling them and pounding them on the table until all are well filled when the ends may be tucked in with a dull awl.

ROMAN CANDLES.

These are probably the moſt popular piece of fireworks made, from a sales point of view. Up to some years ago they were made entirely by hand, that is, one at a time. Then a combination rammer taking a dozen at a time was devised. And later the Candle Machine which handles six dozen was perfected. To make roman candles by hand, roll the cases as described and have a lot of ſtars of different colors ready. Then make some candle composition as follows:

ROMAN CANDLE COMPOSITION

Powdered saltpeter	18 lbs.
Fine powdered charcoal	11 "
Flowers of sulphur	6 "
Dextrine	1 "
Water	1 gallon

After all the ingredients are well mixed and sifted three times add the water and mix again until the whole lot is evenly dampened. Then force through a 16 mesh sieve into cloth bottomed trays and dry in the sun.

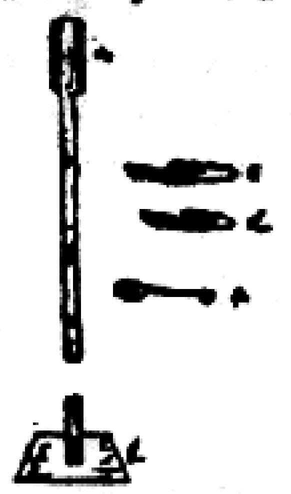

Hand Candle Rammer outfit:

Fig 19

Now provide a ramming outfit as shown in (Fig.19) consisting of a pin block (b), a rammer (a), a composition scoop (c), a clay scoop (d) and a gunpowder scoop (e). The various parts must, of coarse, be proportioned to the size of candle it is intended to make. Say you will begin with an 8 ball. The pin of pin block must be ⅝" diameter. The rammer, slightly smaller so it can pass easily up and down the candle case which also is ⅝". The clay scoop should hold a level teaspoon full of clay; the composition scoop, a heaping dessert spoonful; and the gunpowder scoop should be ¼" diameter and ¼" deep. It may be made from a .22 cal. rifle shell, if desired.

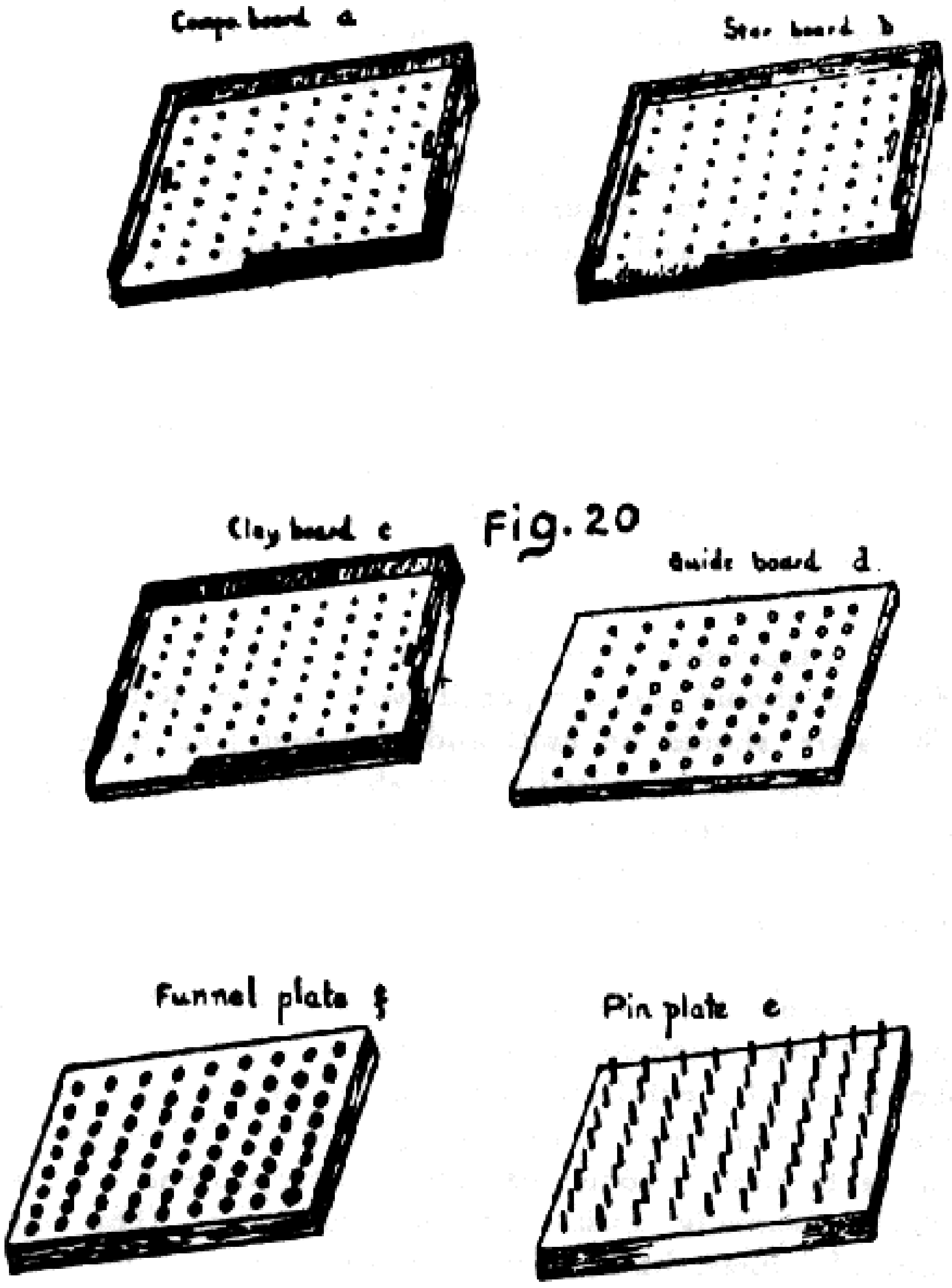


Fig. 20

Now, place an empty case on the pin; pour in a scoop of clay and ram it firmly with a light mallet. Remove rammer; pour in a scoop of gunpowder on top of which drop a star and lastly, a scoop of candle composition. Ram with about six blows of a light mallet. Remove rammer and pour in another scoop of gunpowder, another star and another scoop of candle composition, repeating this until case is filled to within 2" of the top. Remove candle and finish as described under that head.

Hand Combination Candle Rammer.

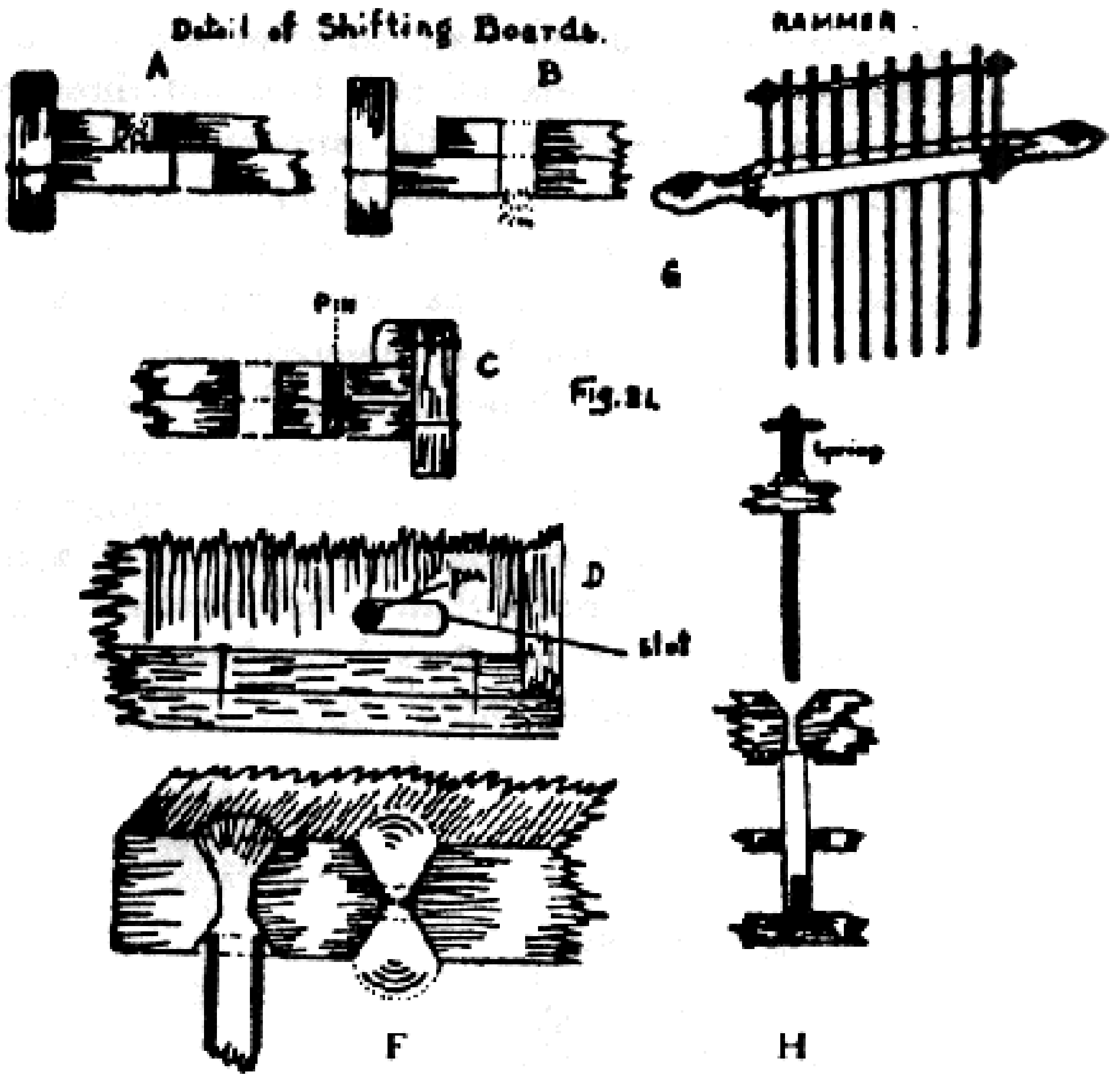


Fig. 21

This consists of an iron pin plate (e), funnel plate, iron (f), a wooden guide board (d), three wooden shifting boards, viz: clay board (c), star board (b), and composition board (a) as well as a gun-powder box (Fig. 23 and 24) and rammer (g). The construction of shifting boards can be readily understood from detail sketch (Fig. 21). The pins shown in upper plates should be understood as being in lower plates. Otherwise slots would become clogged with composition while in use.

The holes in upper board are of a size to contain just sufficient composition clay etc. for one charge (A). This board slides a distance of about ¾" controlled by pin (CD). When upper board is pushed back the holes are filled and when ready to discharge it is drawn forward so the holes are in line with the holes in lower fixed board when the contents falls through funnel into candle being rammed, (B). The gunpowder box is described under "Candle Ramming Machine" so it is unnecessary to repeat its construction. It is of course smaller than the one for large machine and made of size to correspond to pin plate etc. Finally there is the rammer (Fig. 21), (g) consisting of eight steel rods with compression springs fitted through a wooden handle bar as shown, with detail of whole at (H).

This apparatus is used for ramming one to four ball candles and can also be used for serpents and saucissons.

Place pin plate on some solid wood block or concrete base; place guide board over pins so that the holes encircle the pins fairly; slip a candle case on each pin; place funnel plate on top of assembly and raise guide board so as to make cases center nicely.

Now, fill clay board, composition board and star board

Place clay board over funnel plate so holes are in line and shift, tapping lightly so that all clay falls out through funnel plate and into candles. With rammer give 10 to 15 strong blows through each row of holes. Put on gunpowder box and draw plate until a charge enters candles. Then take star board; place as was done with clay board and shift. See that all stars have entered candles and put on composition board. When this has been discharged give about 8 to 10 blows with the rammer, not quite as hard as for the clay. Now give another charge of gunpowder, another board of stars and a second charge of candle composition (if more than 1 ball candles) and repeat until desired number of stars have been used.

CANDLE RAMMING MACHINE.

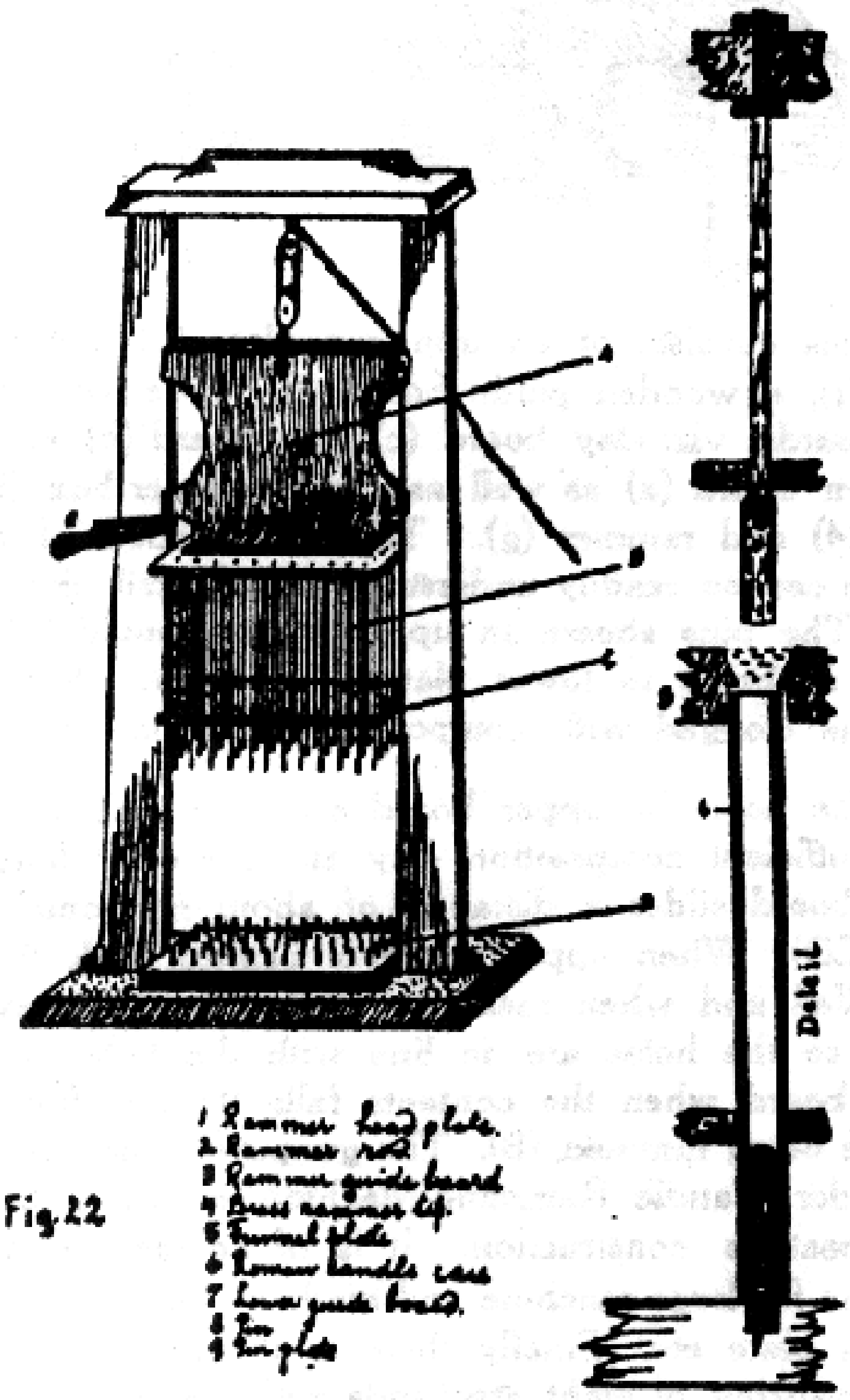


Fig. 22

The ramming machine herewith illustrated was designed in Cincinnati and is used principally for ramming roman candles from 6 ball to 30 ball but up to three ounce rockets may be rammed solid with it and the hollow center of rocket made by driving a spindle into it afterwards as will be explained later. Flower pots may also be rammed with this machine and the writer has adapted it to making 3" cannon crackers at the rate of 72 at a time. However, several sets of rammers of different lengths and thickness are required for the different sizes of candles.

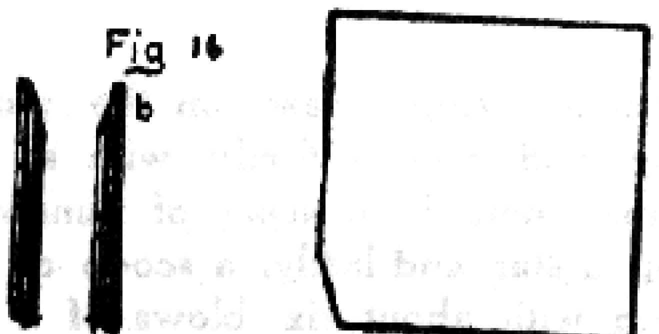
The frame is of cast iron about 7 feet high; the upright sides are 1¼" thick with a V edge on inner sides upon which the head block (A) slides. The rammer assembly is fastened to head block by stud bolts. The guide board (C) is made of ½" lumber and serves to keep the rammers properly in line. This board is loose enough to slip up and down on the rammers while machine is in use. The pin plate (D) rests on base of machine and is slid into place from in front and retained by short stops in the rear. Several of these plates also are required, corresponding with the rammer assemblies as above. The pawl (E) holds the rammers up while the articles to be rammed are arranged below. When all is in place and the first charge of clay (in the case of roman candles) is in the cases an attendent pulls the rope attached to head block, which serves to disengage the pawl. The rammers are now lowered slowly until they enter the funnel plate. The rope is released and as the rammer head falls it rams the clay in the bottom of the cases. From 5 to 15 blows are usually required to ram each charge.

If composition becomes so dry that it will not pack firmly it should be dampened with a very little water. The stars should be hard and dry and free from star dust which can be sifted out by shaking stars in a coarse sieve. The floor of ramming room also should be kept free from all accumulated composition etc. to guard against accidents from friction of the shoes or otherwise

It should here be noted that when cutting the paper for machine rammed roman candles, a thin V shaped slip should be cut from one end (a) of a sheet at side nearest the operator when being rolled. The object of this is to form a somewhat funnel shapped end to case which materially assists its easy ramming. This end must, of course, be uppermost when case is in machine. (a, b) (Fig. 16).

The funnel plate is made of cast iron one inch thick and the other dimensions being the same as head of rammer assembly. It is drilled with 72 holes in 6 rows of 12 each corresponding with the inside of the diameter of the candles to be rammed and spaced same as the rods in rammer head. These holes are countersunk on upper side of plate, to a depth of one third thickness of plate so as to give them the shape of a funnel while the under side is counter bored somewhat larger than the outside of the candles to be rammed, which slip into these recesses and thus are held in place while machine is being operated.

Fig 14



This funnel plate is supported in the ramming machine by an adjustable frame attached to sides of machine, which permits it to be moved up and down as required to fit the various lengths of cases to be rammed. This frame is not shown in drawing of machine.

POWDER BOX.

The powder box (Fig. 23 & 24) is made of brass 3/16" thick and its construction will be readily understood from sketch. The bottom consists of three brass plates, each ¼" thick, drilled with 3/16" holes spaced at same distance as those in funnel plate. The holes in upper and middle plates are ½" nearer the rear of the box than the holes in the bottom plate. The upper and lower plates are fixed but the middle plate moves forward and backward ½". When it is pushed back the holes in it and the top plate are in line, so when the box is charged with rifle powder, the holes in middle plate become filled. When the center plate is drawn forward the holes in it and these in the bottom plate come, into line and the little powder charge in each hole falls out into the roman candle below it. Detail at (Fig. 24) (b).

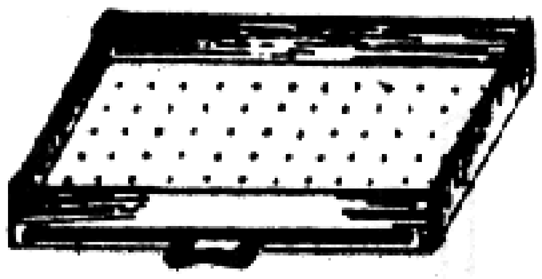


Fig. 23.

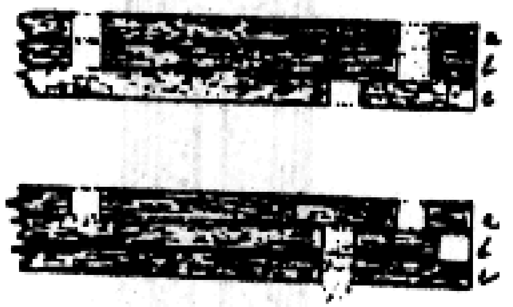
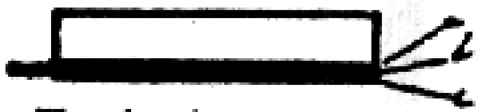


Fig. 24



To facilitate the use of this box it is placed on the adjustable stand (Fig. 25) whereon it can be raised to the desired height for the work in hand. This stand is made of light lumber and preferably on rollers so it may be moved into position and out of the way, as desired between charges.

The shifting boards follow the same principle as illustrated in hand ramming machine relative to arrangement of holes etc. but are of a size to fit other parts of big machine. Boards of different thickness must be provided so as to hold the required amount of composition for the different sizes of candles rammed. The holes in star board should be slightly larger than the stars so as to permit them to fall through easily when in use. The stars for roman candles should be somewhat longer than their diameter as this makes them easier to fall into place when filling a shift board.

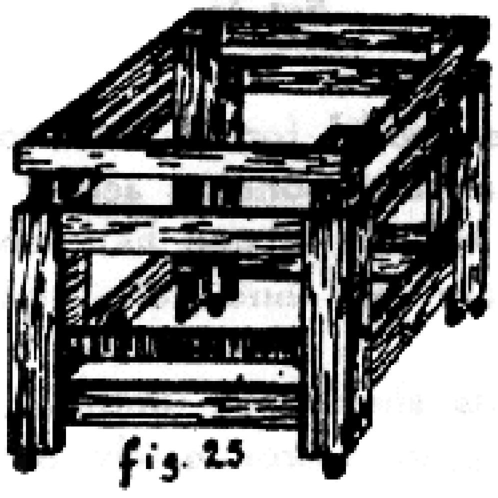


fig. 25

To fill these boards, a scoop of composition or a handful of stars is thrown on top of it; the board is shaken until the holes are evenly filled and the surplus allowed to slide off into the composition or star tray. By using boys to keep the extra pin plates and shifting boards filled as quickly as needed, and others to remove the loaded candles, a very large number of them can be loaded in a day, by one machine. A pin plate of candle cases is slipped on to the base of the machine; the funnel plate is lowered on top of it; the guide board is raised, causing the ends of cases to enter the funnel plate which is fastened in place by set screws or thumb bolts on sides of frame. The rammer head is allowed to decend sufficiently to see that all is clear. It is drawn back up into place and a shifting board of clay slipped over and its contents discharged into the candles, a slight jar being given to assure all holes of having emptied. The rammer head is now dropped some 10 or 12 times to set the clay, and withdrawn to its original position. The powder box is now slid across funnel board and by pulling handle of center plate a charge of gunpowder enters the candles. After removing powder box a board of stars is shifted into the funnel plate. Care must now be used to see that all stars have slipped through funnel plate into candles. Now a board of composition is discharged the same way and the whole rammed with about 8 to 10 blows. This operation is repeated as often as the size of candle requires. When last charge of composition has been rammed the pin plate of candles is removed, unloaded and refilled with empty cases while another pin plate of empty cases has been slipped into its place in machine.

BATTERIES.

A very effective piece of fireworks (Fig. 26) easily made by taking a wood box about two inches longer than the candles to be used and filling it with about three dozen 8 ball or 10 ball roman candles. The space above the candles in the box is to be filled with a few scraps of match, one piece allowed to hang over the side and a piece of cardboard nailed over for a top.

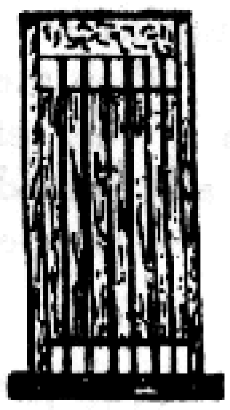


Fig. 26

BOMBETTE FOUNTAINS.

These are an effective combination of candles and floral shells packed in a large box as shown in (Fig. 27).

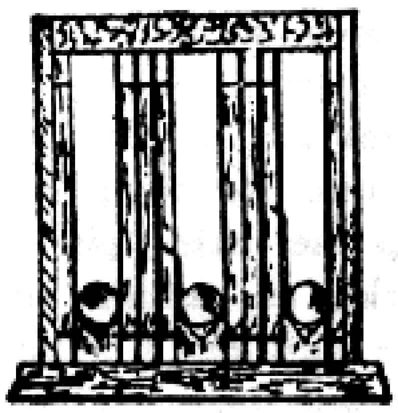


Fig. 27

All are lighted at once by scraps of match in the top, but the floral shells are matched so as to fire alternately, one at a time as shown, during the burning of the candles.

Another interesting use for roman candles is in the so called union battery (Fig. 28) which consisted originally of one battery each of candles containing white, red and blue stars. It is however, now used effectively with candles of varigated stars.

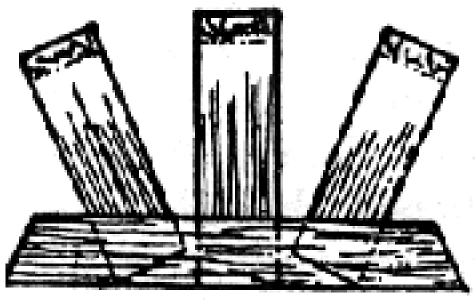


Fig. 28

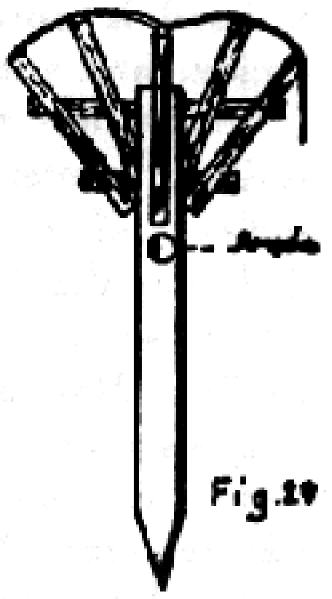


Fig. 29

BENGOLA BATTERY.

Fireworks displays are often started with a row of vari-colored lights or bengolas set about 25 feet apart in front of the set pieces. When these are supported by a fan of candles or gerbs a very effective display is produced. The bengolas are lighted first and when they have burned half way, the candles or gerbs are lighted. (Fig. 29)

SKY ROCKETS.

Next to roman candles, these are perhaps the most popular article of the pyrotechnical craft and on good authority, seem to have antedated the candle. So much has been written about sky rockets that any general description would be superfluous. The French, in particular, have left a most detailed history, sometimes amusing in view of present day conditions, regarding its manufacture.

Suffice to say that the rocket consists of a tube of paper, rammed with suitable composition, its lower end choked to about one third the diameter of its bore and a hollow center extending upward though the composition to about ¾ inch of the top. A stick attached to the tube serves to balance it while ascending. Broadly the composition of a rocket, that is the portion of it which burns while it is ascending, should be seven times its diameter, in length. Six sevenths is pierced through the center while one seventh is solid and acts as the fuse to communicate the fire to the heading when rocket reaches the highest point of its flight. The tube is made of good strong paper, preferably three turns of hardware on the inside with four or more turns of good strawboard on the outside, but a good rocket case can be made of heavy rag or building paper if properly rolled with good paste. Choking the case and ramming in mold has been practically discontinued.

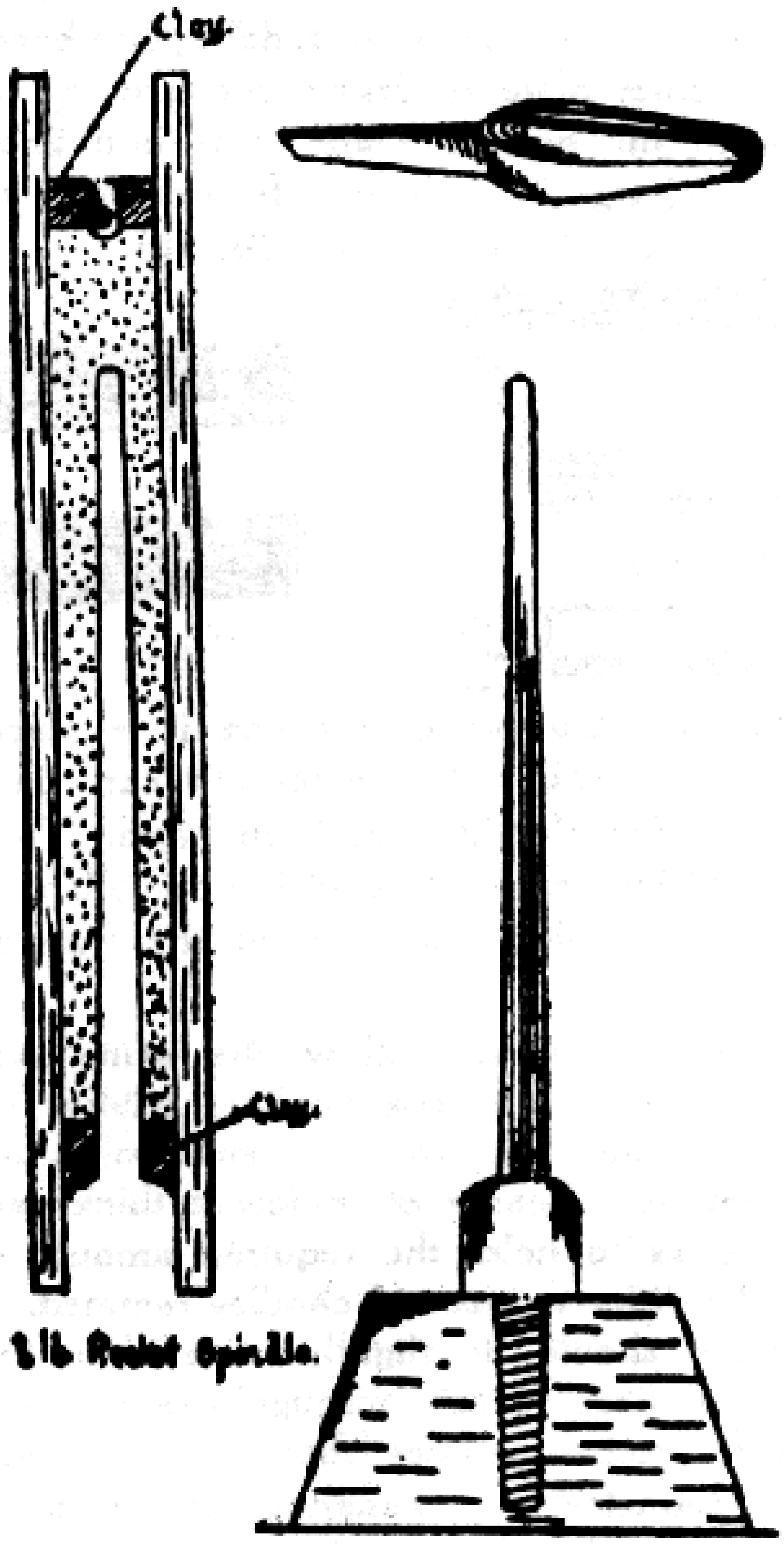


Fig. 30

An average model for a 1 lb. rocket is given in (Fig. 30) with a corresponding set of ramming tools in (Fig. 31). The spindle is one half actual size while the ramming tools are one third actual size.

Good rockets should be uniform, all those of one caliber ascending to approximately the same height and exploding at about the same time. Particularly is this desirable in bouquets or flights of 100 or more fired simultaneously, else a straggling effect is produced.

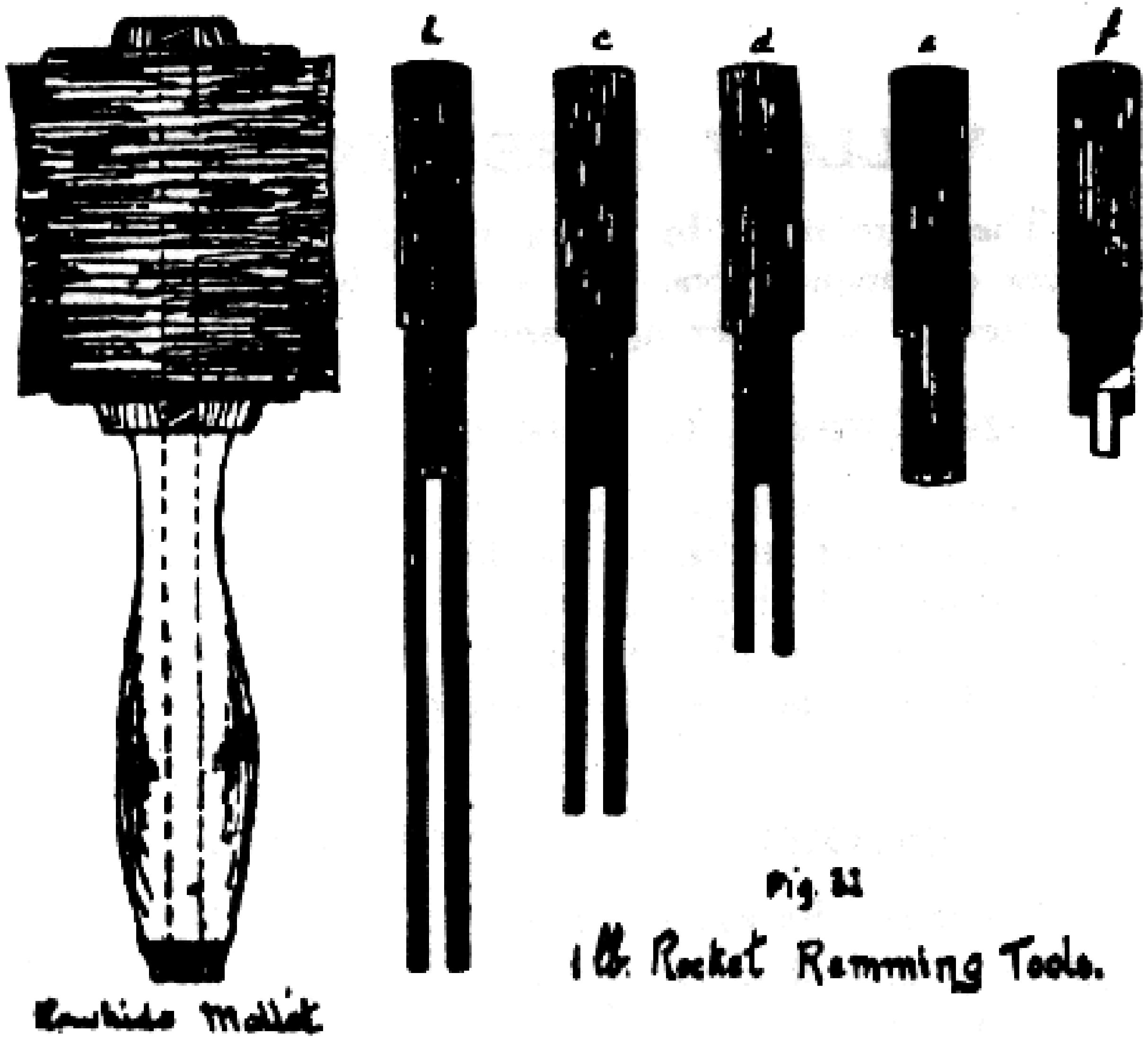


Fig. 31
1 lb. Rocket Ramming Tools.

Most rockets larger that 3 oz. are rammed singly or by gang rammers as shown in sketch (Fig. 32) but hydraulic rammers are also in use. See Military Pyrotechnics, H. B. Faber, Vol. 2 pp. 39.

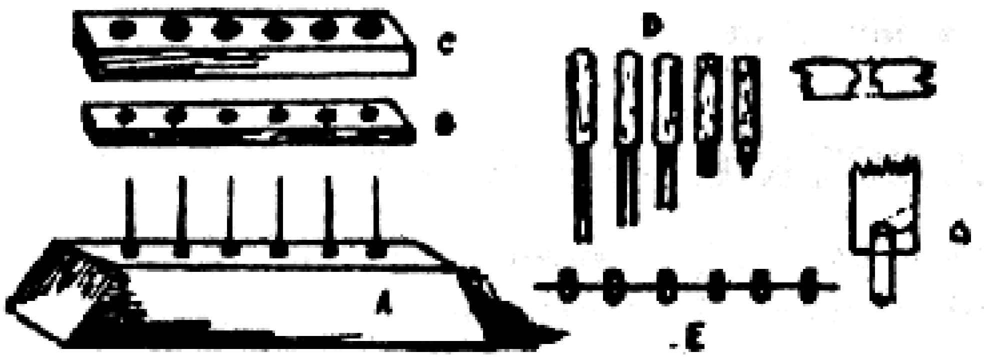


Fig. 32

The gang rammer is quite efficient and one man can get out a large number of rockets in a day with it. A shows the spindle block; B is the guide board for assisting to get the ends of cases into funnel piece C. D shows a set of rammers while E is the set of scoops for charging the entire six cases at once. It is easily made by cutting brass shotgun shells in half and soldering them to brass rod as shown. Details of funnel piece and hollow pin rammer used in setting top clay charge are shown at F and G respectively.

1 oz. to 3 oz. rockets are rammed solid on the candle machine or otherwise and the hollow center is made by driving a steel spindle into them afterwards. These must have their lower ends choked as explained on page 41. An efficient way of doing this is to get a mortising machine and replace the chisel with the spindle as above. A V shaped block is set on table of machine, in such a position that when a rocket is placed on it, it will be in just the right position for the spindle to enter it. A step on the pedal of mortising machine will force the spindle into the rocket and make the necessary hollow center.

To ram rockets from 4 to 8 oz. singly the case is slipped on the spindle illustrated under sky rockets; a scoop of clay is shaken in and rammed by about eight good blows of the mallet on the longest rammer. Then a scoopful of composition is rammed with about eight lighter blows. This is repeated until the case is filled to within about 1 inch of the top, shifting rammers as it becomes possible to use shorter ones. Now the final charge of clay is put in and the hollow pin rammer used. This sets the clay while leaving an opening for the fire to reach the heading. Care must be taken to see that the hollow tube just pierces the clay. If it does not go through, the heading will fail to fire; if it goes through too far, heading will fire prematurely or rocket is liable to blow through before rising.

The following are good compositions for rockets of different sizes:

	1 to 3 oz.	4 to 8 oz.	1 to 3 lb.	4 to 8 lb.
Saltpeter	18	16	16	18
Mixed coal	10	9	12	12
Sulphur	3	4	3	3

If rockets burst add more coal; if they ascend too slowly add more saltpeter. For the smaller sizes use fine coal; for the larger ones use coarser coal in proportion to their diameters. 4 lb. to 8 lb. rockets use granulated saltpeter.

All rockets larger than 3 oz. are provided with a cone to contain the heading. These are made as follows:

SKY ROCKET CONES

Turn out a cone former on the lathe, of a shape somewhat as shown in Fig. 33. Cut some stiff paper to the shape of one third of a circle, the radius of which for a 1 lb. rocket should be 3 inches. Lay it on the table before you with the round side toward the right.

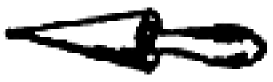


Fig. 33

Paste the straight edge farthest from you and place the former on it with the point toward the left and about ¼" from the point on the paper where the two straight edges meet. Now roll it around the former commencing with the unpasted edge. When finished slip off former to dry.

HEADING ROCKETS

Prepare a board with holes through it about 1¼" in diameter and raised from the table about 3" as shown in Fig. 34. Place in these holes a number of the cones, point down, and fill them about half full of stars, gold rain etc. Also a little meal powder and charcoal or candle composition. Apply gum to the upper edge of a rocket and stick it into one of these cones. Raise carefully out of the hole and press cone evenly in place. The rocket may now be wired to stick and is ready for use. In the case of shelf goods the rockets are of course papered and matched before attaching cones.

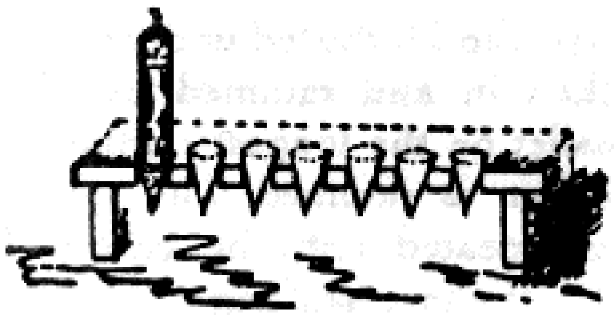


Fig. 34

SHORT STICK ROCKETS.

These are the same as long sticks except that a stick only ½ the regular length is used, on the bottom of which a wing or tab of cardboard is attached (Fig. 35a). Cut a piece about 3" long, 1½" wide at one end and ½" wide at the other. Smear a little dextrine on one end of stick, place the tab on it, large end down and drive a 2 oz. tack through it in the middle. When dry it is ready for use. These rockets are much easier to carry about but require more care in firing to get them started straight.

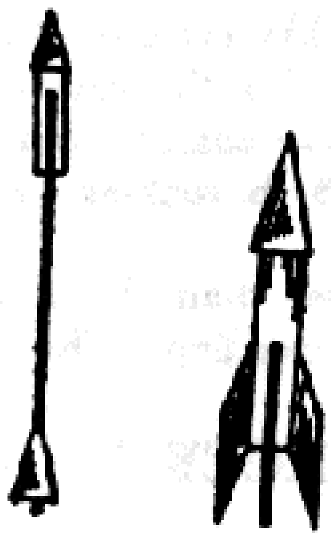


Fig. 35a.

The one illustrated at right (Fig. 35a) has no stick at all, only four wings, upon the ends of which it rests when lighted.

When the bottoms of brass rammers become worn from use, they may be reconditioned by battering them until they are again full sized on the ends.

There are a great many of so called fancy rockets in which the heading is not confined to a simple burst of stars etc. but is supplemented by many other beautiful effects, some of which will be described here while the ingenuity of the pyrotechnist must be relied on for others.

WILLOW TREE ROCKETS.

These are made by filling a large rocket head with pieces of Japanese Star and a weak bursting charge. If the bursting is too strong many pieces will fail to light.

Prize Cometic, or Shooting Star Rockets.

These are prepared by placing 4 or 5 four ounce rockets, without sticks, in the head of 6 lb. rocket besides a handful of box stars. A few #1 stars are also placed in the top of each of the 4 oz. rockets with a pinch of grain powder, and well capped.

GOLDEN CLOUD ROCKETS.

For these the rocket head is filled half full each of gold rain and aluminum stars. The weight of the contents of a rocket head must be proportioned to the size of the rocket. A heading of heavy stars must be smaller than one of lighter materials.

BOOM ROCKETS.

Have one or more small maroons in the head besides a few stars.

ELECTRIC SHOWER ROCKETS.

Made by filling a small head with electric spreader or granite stars. As these are very heavy only a small quantity can be used.

BOMBSHELL ROCKETS.

These have a small shell with very short fuse fastened to top of rocket, with a few stars in the head of the rocket itself, which burn before the shell bursts.

WHISTLING or CALLIOPE ROCKETS.

The head of this rocket is filled with whistles, made as described under that caption. In addition, a few colored stars are added.

LIQUID FIRE ROCKETS.

These are one of the most beautiful pyrotechnical effects known to the art. Take a 3 lb. rocket and fill the space above the clay with grain powder. Cover this with a circular piece of perforated paper secured by a strip of tissue paper. Roll on a head of about three turns of strong manilla paper, only pasted on the edge, about 6" long. Now procure some sticks of phosphorus and cut them under water with a chisel into pieces about ¼" long. Get some ¼ lb. tin cans, punch a number of holes in the bottoms of them and fill with the pieces of phosphorus, conducting the entire operation under water. When ready to fire the rockets remove one of the cans from the water, allow to drain for a few seconds, empty contents into one of the rocket heads tuck in and fire at once. Great caution must be observed owing to the dangerous nature of the phosphorus.

PARACHUTE ROCKETS.

To successfully launch a parachute from a shell or rocket requires the greatest care and skill, besides patient attention to every detail or the light fabric will either fail to unfold or be torn or burned in its exit from the tube in which it is placed. To begin with procure some very light Japanese tissue paper; cut into spuares about 18 inches each way and rub thoroughly with powdered soapstone.* Cut four pieces of stout linen twine or shoemakers thread about 18" long. Twist the corners of the tissue squares a little and tie a thread to each. Draw the other four ends of threads together and tie them in a knot. The parachute is now ready to fold. In one hand take the knot where the four strings meet and in the other take the top of the parachute by the center. Draw the hands apart until the paper folds together and lay on the table in front of you. Straighten out the four folds, two each way, and fold them again laterally toward the center about five or six times like the bellows of an accordeon until the pile is about 1 inch wide. Now roll this up lightly beginning at the small end or tip until you come to the strings, then wind the four strings, also lightly, around the bundled parachute until it will just about fit the rocket head for which it is intended.

For making the light ram a short case ¼" diameter and 1" long with box star composition. Prime one end and stop the other with clay. Over clayed end glue a cardboard disc slightly smaller than inside diameter of rocket head, having first passed a wire through the case under the disc so as to form a loop on exposed size as shown, (Fig. 35). Pass about 18 inches of stout linen twine through the wire loop and tie the other end to the knot on the parachute where the four strings come together. Roll a piece of naked match about 18" long, into a bunch and place it in the bottom of the rocket head for a blowing charge. On top of this drop the primed end of the parachute light and over it place a small wad of cotton waste and a little cotton hulls or bran. Now slip in the parachute around which the strings have been lightly wound. Fill all around parachute with bran and secure the top of rocket head very lightly so the parachute will be thrown out when discharged, with the least possible effort.

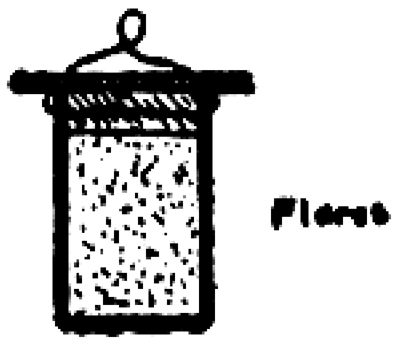


Fig. 35

CHAIN ROCKETS, (Caterpilars).

If you have succeeded with parachute rockets you may now attempt this modification of the above which is infinitely more difficult but their great beauty compensates for the trouble required in their preparation. A parachute several times larger than the first described is made in substantially the same manner but preferably octagonal with the separate pieces sewed together. Instead of one light, a dozen or so of different colored lights are attached to it. This is called the chain and to launch it successfully from either rocket or shell is about as difficult a proposition as the pyrotechnist is called upon to execute.

For the lights composing the chain ordinary lances may be used. To a 4 lb. rocket take 12. Procure a strong linen twine about 18 feet long. To this attach the lances at intervals of about 1½ feet, by taking two half hitches around the bottom ends. (It is best to make special lances for this purpose, filling the first ⅛ inch at the bottoms with clay). When all are fastened, tie one end of chain to parachute and at the other begin to wind up the slack between the lances. Wind each lance with the slack between it and the next one to it, winding as smoothly as possible without lapping the twine anywhere. As each one is wound lay it against the other one before it until the 12 are in a round bundle. Then take a few turns around the entire bunch on upper end, so as to hold it together. At the bottom end of bunch take two turns of light cord not more than ¼ inch from the end. This is to hold the lot together until the lights all take fire when this cord burns off and chain unwinds in the air. A cardboard wad fitting easily in the rocket head and with a hole through its center is placed on top of the primed ends of the bunch of lances and a piece of match passed through the hole in same so as to touch them. This may be fastened in place with a small tack or two.

Now prepare the rocket head for the reception of the chain, as directed for parachute rockets, by placing about 2 feet of naked match in bottom of head for the blowing charge. Slip the bunch of lances on top of this with another paper disc, through which line runs, over it. Put in a good wad of cotton waste, then the parachute carefully folded as described and pack with bran. Now cap the rocket head as lightly as possible and if all directions have been carefully followed, the chain will be likely to come out successfully. A few trials, however, are generally necessary. Sometimes four light sticks are inserted in rocket head alongside of the parachute the lower ends resting on a stout wad under the bunch of lances and the other ends against top disc over parachute. This is to keep parachute from being injured while being expelled by blowing charge.

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*Ready made parachutes may now be purchased from stock.

BOUQUET or FLIGHT of ROCKETS.

These are made by firing a hundred or more rockets at once from a specially prepared box. Take three boards of ½" lumber, 12" wide and 4 feet long; clamp two of them together and with a ½" bit bore 5 rows of holes 2 inches apart and beginning 2 inches from the sides and ends. This will make 100 holes through the boards (B). Now make a box, the bottom of which is made of one of the boards with holes through it as shown in (Fig. 36), (A). Attach four legs to the box, about 4½ feet long. At 1½ feet from the bottom secure the other board with the holes in it, (B) so that a rocket passed through a hole in the box bottom may be steadied by passing through corresponding hole in lower one. Fit the third board (C) in the legs also, about 6 inches from the ground to make a resting place for the rocket sticks and so as to hold the bottoms of the rockets in box, about one inch above bottom board (A) of box. This is to permit the fire to reach all the rockets instantly when flight is lighted.

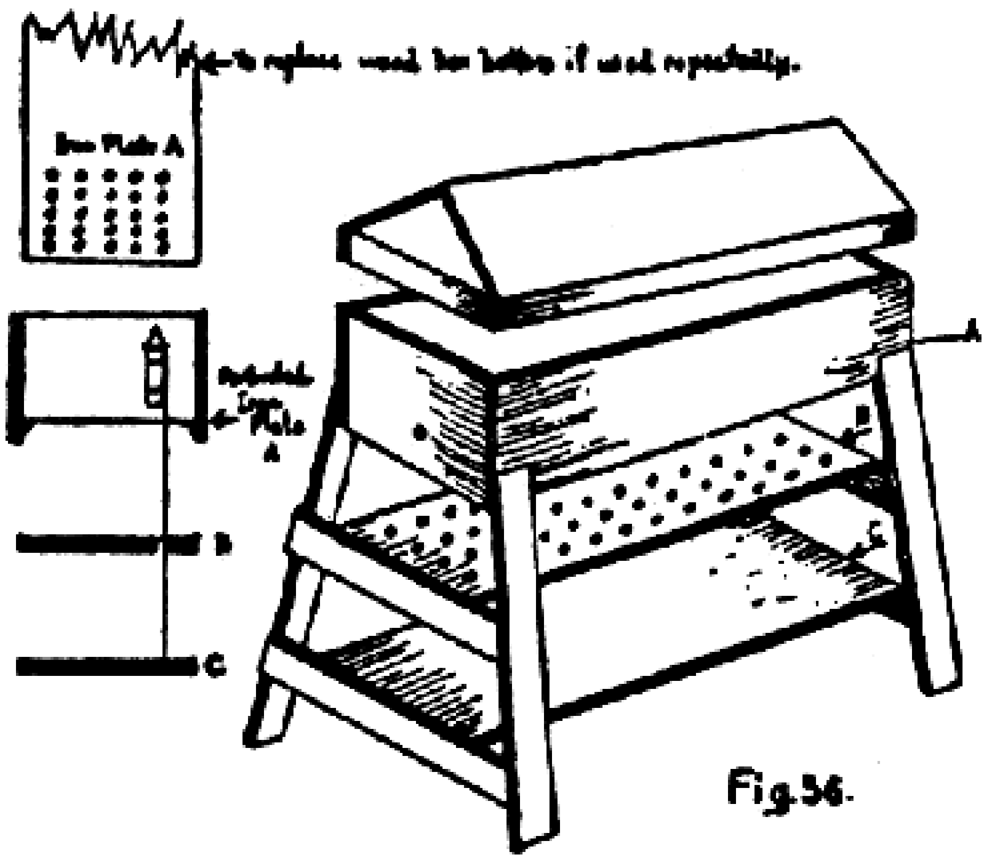


Fig. 36.

Flight rockets used this way need not be matched; only primed and a little loose grain powder thrown on bottom, inside of box and a piece of match passed through a hole in side to fire it from is all that is required. If a top, covered with canvas, is fitted to flight box, same may safely be left in the rain until required. Some pyrotechnists make flights by stringing rockets in a row on slats provided with nails to hold them apart but the effect in much inferior.-

ROCKET STAND.

The best method of firing sky rockets is from a wooden trough constructed of two light boards, ½" thick, 4" wide and 6' long. These are nailed together so as to form a gutter and supported by two legs. If the boards and legs are hinged as shown in Fig. 37 the trough may be folded and easily carried about.

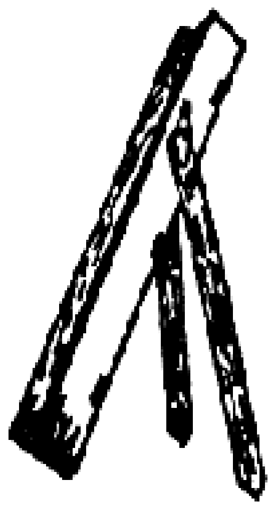


Fig. 37

TOURBILLIONS.

(Geysers, Whirlwinds, Table Rockets)

This is a modification of the sky rocket and ascends to a height of about 100 feet, in a spiral manner and without a stick. They are made by ramming a 3 lb. rocket case with one of the following mixtures:

Saltpeter	8	5
Meal powder	7	12
Charcoal	2	3
Sulphur	2	3
Steel filings	3	

Both ends of the case are stopped tight with clay. Four holes are bored in it, ½" diameter. Two are bored into the bottom, 3" apart or 1½" each way from the center and one hole on each side, 1" from end and opposite to each other as shown in sketch (Fig. 38). A piece of curved stick, as long as the case is nailed to the bottom of case, concave side down exactly in the center and at right

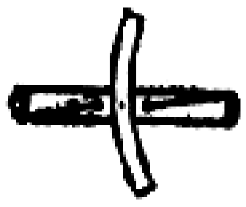


Fig. 38

angles with same. The holes are primed and while still wet it is matched by tacking a piece of quick match to one of the bottom holes, passing it to the nearest end hole; then over the top to the other end hole and finally to the other bottom hole. A small hole is now made in the match pipe as it passes over the top of case, just in the center, into which a short piece of naked match is slipped for lighting. To fire a tourbillion it should be laid on a wide board or smooth surface stick down and lighted with a long portfire.

Small tourbilliens are sometimes made by boring only two holes in the under side of case, at an angle of 45° from the perpendicular, but those with four holes, especially in the larger sizes are safer and more likely to function. They may also be matched by using naked match all around and afterwards covering the whole tourbillion with tissue paper pasted and pressed closely to same. Large tourbillions are sometimes further beautified by placing a few stars in the ends of the case, outside of the clay, boring a small hole through same and securing over top with strong paper and a wad. A little meal powder is put in with the stars and when the tourbillion reaches its height, these are thrown out with fine effect.

FLYING PIGEONS.

This amusing piece of fireworks is easily made in its simplest form by securing two rockets with their openings pointing in opposite directions, to an empty case as shown in Fig. 39 (a). The rear end of one is connected by a piece of match to the front of the other. A piece of thin rope or telegraph wire is stretched between two posts about 20 feet high and 300 feet apart. One end of wire is previously slipped through the empty case forming the middle of pigeon. On lighting the first rocket the pigeon will run along the line until the other rocket lights when it will return to the starting point.

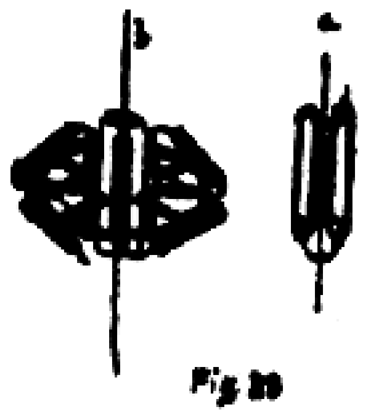


Fig 39

A more elaborate form of pigeon (b) is made by procuring a frame as shown. This consists of a vertical wheel frame with a heavy slotted hub. A row of 4 wheel cases are fastened to the rim and four 1 lb. rockets are secured to the long slots in hub, two pointing each way. The pigeon starts with one of the wheel cases, the rear end of which is connected to one of the rockets. This in turn is matched to the second wheel case and that to the next rocket, pointing in the opposite direction, and so on to the last rocket.

English Cracker or Grasshopper.

Cut some good 20 lb. 24" x 36" manilla or kraft paper into strips 4" wide and 12" long. If cut with the grain of the paper as it should be this will give 18 cuts from one sheet. Roll them into short tubes as directed for match pipes, getting the opening at one end, somewhat larger than that at the other. This may be done by rolling a V shaped strip of paper on one end of rod. When a quantity of these tubes have been rolled close the smallest end by twisting or folding it over. Dry them in the shade and put about 12 dozen in a bundle, all the open ends one way. Stand the bundle on a large sheet of paper with the open ends up and pour FFF rifle powder on top of it until all the tubes are full. Jolt bundle occasionally to be sure none are only partly filled. Then draw them out, closing the top end as you did the bottom and wrap them all in a wet towel, setting aside in a damp cool place for several hours. A good way is to take a long cloth, wet it well, spread the loaded pipes loosely on it and roll it up so that each pipe will touch part of the wet cloth as they should be moistened through but not wet before proceeding further. When this condition has been reached (on which the whole success of the operation depends) run them through a clothes wringer or other roller so that they will be somewhat flattened. The exact amount of flattening can only be found by experiment.

Now take a piece of wood, say 1" thick and 4" wide by 18" long. Notch out a piece as shown in Fig. 40 1¼" wide and 6" deep and procure a dozen pieces of stiff wire 4" long. Lay the lower ends of a half dozen of the damp pipes across the bottom of the notched board which has been fastened in an upright position to a bench. On top of these and against one side of the board lay a wire and bend the pipes across over it until they now point in the opposite direction. Lay another wire as before but on opposite side and repeat the operation until the entire length of the pipes have been folded up. Then take a bar of wood shaped as shown in sketch and, holding one end in each hand press the folded pipes down as hard as possible so as to have the turns well formed. Now lift out the folded bunch, wires and all. Remove wires, fold bended pipes, one by one in the

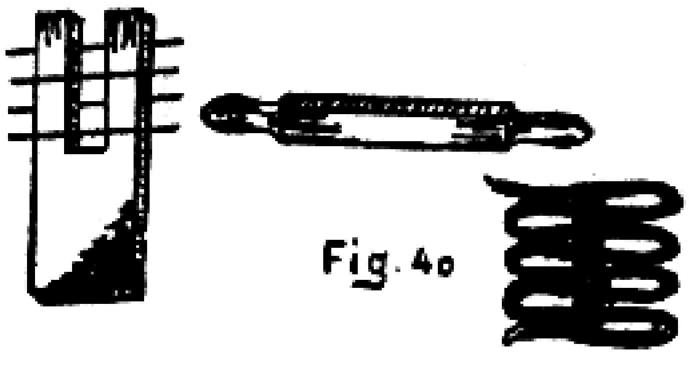


Fig. 40

hand and with linen shoemakers thread secure them by wrapping half a dozen turns around the folded pipe and finally pass a few turns between the folds. Strip off one end so the powder is exposed and prime it with a little wet powder or match it; or the end may be twisted up with touch paper, made by coating unglazed paper with a solution of saltpeter, before folding. When dry crackers are finished.

In this country a cruder form of cracker is made by taking suitable lengths of covered match, damping and folding it like the crackers described, tying and leaving a short piece of match protruding for lighting it.

PIN WHEELS.

Fig. 41

For making these proceed just as described for English Crackers except using the following composition instead of gunpowder for loading them:

Meal powder		10	8	2
Fine grain powder	8	5	8	
Aluminum			3	
Saltpeter	14	4	16	1
Steel filings	6	6		
Sulphur	4	1	3	1
Charcoal	3	1	8	

When they are dampened and rolled out punch out a lot of round pieces of #60 strawboard, with a hole through their center. Then get a piece of brass, the same size as the cardboard centers and fasten it to the work table. Lay one of the centers on this brass plate and taking a filled pinwheel tube press the smallest flat end against its edge and twisting it around disc with the right hand while left hand feeds the tube as it is being wound on, continue until all the tube is rolled around the center. The brass plate should be half as thick as the finished pin wheel so the cardboard center will be held just about in the middle of the pinwheel while it is being twisted.

Now have some boards prepared with strips of wood ¼" square, nailed on them, the same distance apart as the width of a pinwheel when it is lying down. When the wet pinwheel is twisted up as above, lift it off the brass plate and set it between two of these strips on the board so as to keep it from untwisting and with a brush put a drop of glue across the pipes and onto the center disc, at four equidistant points. When they have dried they may be removed from the boards and are ready for use. (Fig. 41).

SERPENTS or NIGGER CHASERS.
(Squibs)

These are light strong cases, 3" to 5" long, crimped at one end and charged with a sharp composition, strong enough to cause them to run around on the ground or in the air while burning. They may be made from #140 strawboard, heavy manilla or rag paper and crimped while still wet. (Fig. 42).

Fig. 42

They may be rammed singly with rod and funnel or in batches of 72 at a time with the hand combination rammer, q. v. Alternate compositions are:

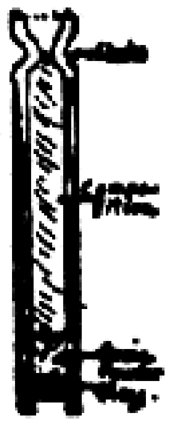
Meal powder	3	3
Saltpeter	2	5
Sulphur	1	1
Mixed coal	1½	¼
FFF grain powder	4	3

SAUCISSONS.

These are very similar to serpents but somewhat larger and always end with a report. The usual length is 3½" with a diameter of ⅜" to ½", rolled and crimped like serpents though with a heavier case.

Ram with,	Meal powder	4
	Saltpeter	2
	Fine coal	1½
	Sulphur	1

For exhibitions, about three dozen of these are put in a paper bag with three onces of blowing charge composed of half meal powder and half grain powder. A piece of match a yard long, bared for an inch or two is stuck into the mouth of the bag and tightly secured with a string. When ready for use it is loaded into a mortar and match ignited.



Saucisson

Fig. 43

For stock work a paper mortar is made by rolling six or eight thicknesses of heavy strawboard 12" wide around a former 2½" diameter. A wooden bottom is fitted and a mine bag made as described under MINES. The saucissons are placed in same with blowing charge, around a 10 ball roman candle from which the bottom clay has been omitted. This is placed in the paper mortar with a daub of glue on bottom of bag. A top is fitted as for mines and when papered and striped, is ready for the market.

MINES.

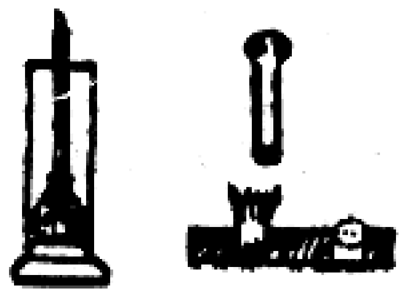
These are small paper guns from 1" to 3" in diameter in the bottoms of which are placed small bags of stars powder etc. which are fired by a mine fuse or roman candle in which the charge of clay has been omitted and replaced by one of candle composition. The bottoms are turned out of wood. The tubes are made by tightly rolling six to twelve thicknesses of strawboard, around a suitable former. Following are approximate sizes:

NUMBER	HEIGHT	DIAMETER	NUMBER OF STRAWBOARD
1	4"	1½"	1 sheet #140
2	4¾"	1¾"	1 " #120
3	5½"	2"	1 " #100
4	7"	2¼"	2 " #100
5	8½"	2⅜"	3 " #100
6	10"	2⅜"	4 " #100

No. 1 mines take a 1 ball mine fuse; No. 2 mines a 2 ball fuse fuse etc.

The mine bags are made by boring a number of holes into a thick board; (for #1 mines, 1¼" diameter and 1½" deep). Then make a punch with rounded edges; (for #1 mines, 1" diameter) and over this press a piece of stout paper (about 4" square) closely around end of punch and shove it into one of the holes in the board; remove punch; insert a mine fuse and around it put a half once of stars and a teaspoonful of blowing charge. Squeeze loose ends of bag around fuse and secure with a piece of string or wire. Now daub the bottom of bag with a little dextrine or glue and insert it in one of the paper guns into which a bottom has been previously glued. A top is now necessary. This is made by adjusting an ordinary washer cutter to the requisite size so as to cut a piece of strawboard with the outside diameter of the gun and center hole of the size of the mine fuse When this is slipped into place over the fuse it is secured by a square piece of paper, an inch or two larger than the top of mine and with a hole punched in the middle with a wad cutter, to fit over mine fuse. Paste and press closely about the top of mine and when dry same is ready for use. For stock work they must, of course, be papered and striped, packed and labeled. Mines of saucissons are made by substituting saucissons for the stars. (Fig. 44).

Fig. 44.



DEVIL AMONG THE TAILORS.

These are made by taking a large short mine case and filling the bag with tailed stars, serpents and English crackers. Besides the central candle for firing it, four more candles, one at each corner on the outside of gun are fastened and connected so as to burn at same time. (Fig. 45).

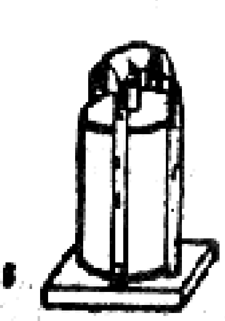


Fig. 45

ANGLO JAPANESE MINES.

These consist of a #6 mine case containing a bag filled with colored stars and Japanese or Willow Tree stars. Electric Spreader stars with crackers also make a handsome mine. The various effects are almost unlimited and the genius of the artificer will suggest other combinations

Fountains, Flower Pots and Gerbs.

These are all modifications of the same principle which is a paper tube or case varying from ½" diameter to 2" diameter rammed solid with one of the compositions to be given later.

FOUNTAINS.

Are usually from 1" to 1½" diameter and 12" long with a wooden point in the lower end so they can be stuck in the ground for firing. A quarter ounce of rifle powder is sometimes placed after the last charge of composition and before the clay, both in fountains and gerbs so as to have them finish with a report or "bounce".

Besides the regular composition with which fountains are charged, if the calibre permits, small colored stars cut to about ¼" cubes and placed between the charges when ramming, greatly increase their beauty and they are then called FLORAL FOUNTAINS or PRISMATIC FOUNTAINS. There is however, some danger in ramming stars containing chlorate of potash with compositions containing free sulphur and this may be avoided by using compositions free from chlorate, such as granite stars, copper borings etc. or perchlorate compounds.

Cascade cases are used for water falls and such designs where the fire is required to fall considerable distances to the ground. They are usually from 1½" to 2" diameter and 12" long. Where this piece is to be often repeated as at Fairs, iron tubes 2" inside diameter are sometimes used as these are stronger and can be cleaned with kerosene after using for repetition. Where Niagara Falls is shown this form of case is in general use as it saves the rolling of 200 to 300 large cases for each display.

FLOWER POTS.

Fig. 47

Small cases, choked, ½", ⅜" and ¾" diameter and from 5" to 10" long with a wooden handle in end provide a pretty piece of fireworks for use by ladies and children. When properly made they are perfectly safe to fire from the hand but this fact should be assured by first firing a few by sticking them in the ground, to see that the charge is not sufficiently strong to burst the case. The lampblack in these produces a peculiar effect not entirely understood.

It might be well to mention that when ramming gerbs etc. it is advisable to begin with one charge of starting fire especially where the composition contains steel, as they not only sometimes miss fire but there is also the likelihood of striking fire by ramming steel filings against a metal nipple.

GERBS.

These are used for all set pieces where brilliant effects or jets of fire are desired. They should be about ¾" diameter and 9" long. When steel filings are used the steel should be first protected q. v. as the saltpeter corrodes the filings which affects their brilliancy. They are rammed like rockets but on a short nipple without central spindle. Use the following formula.

Fig. 48

STARTING FIRE FOR GERBS

Meal powder	4
Saltpeter	2
Sulphur	1
Charcoal	1

GERBS.

Meal powder	6	4
Saltpeter	2	
Sulphur	1	
Charcoal	1	1
Steel filings	1	2

FOUNTAINS.

Meal powder	5
Granulated saltpeter	3
Sulphur	1
Coarse charcoal	1
FF rifle powder	¾

FLOWER POTS.

Saltpeter	10
Sulphur	6
Lampblack	3
FFF rifle powder	6

CASCADES.

	1½" case	2" case
Granulated saltpeter	18	16
Mixed charcoal	4	4
Sulphur	3	3
Iron borings	6	7

WASP LIGHT.

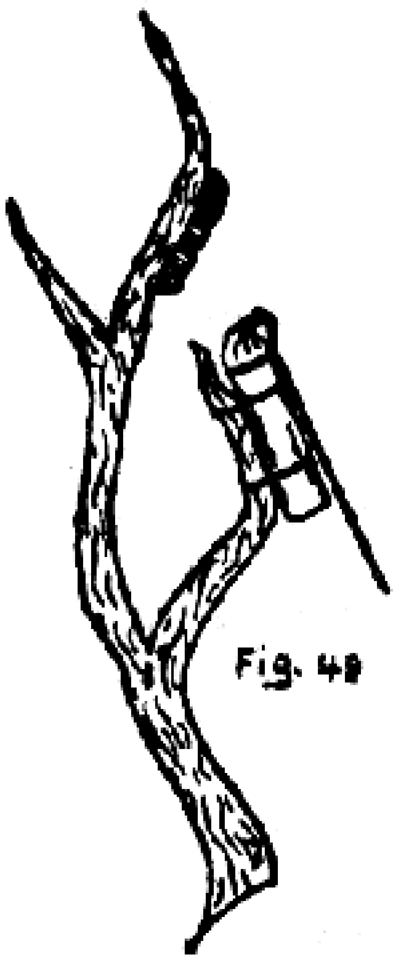


Fig. 49

This contrivance a very effective and safe method of destroying the nest of wasps, hornets etc. The sketch illustrates the method of using same and the following composition is satisfactory.

Saltpeter	9
Sulphur	1½
Charcoal	5

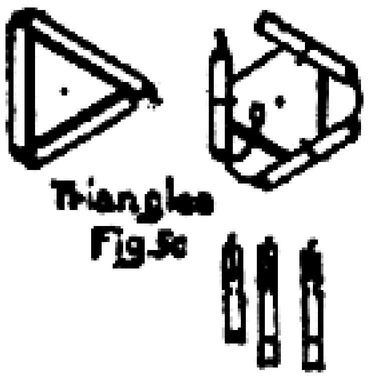
Where it is not practical to attach the light as shown, a long pole may be used. Tied to the end of a fishing rod and brought in contact with a nest it will destroy it without danger to the operator as the burning composition completely demoralizes the insects who make no effort to sting.

The case should be about ¾" diameter and 5" long rammed on a nipple like a gerb. (Fig. 49).

REVOLVING PIECES.

Triangles.

These are made in two forms, (Fig. 50) (a) consisting of a small six sided block with concaved groves on three of its edges' into which small choked cases are fastened, either by glue, wire or nailed; and (b) consisting of a triangular block on each side of which a serpent is fastened. The serpents must be rammed full and primed at both ends, except the last one. A piece of paper is pasted over the joints where the two ends meet, of second and third cases and first one is matched with a small piece of match for lighting. The blocks have a hole through their center for the nail on which they revolve.

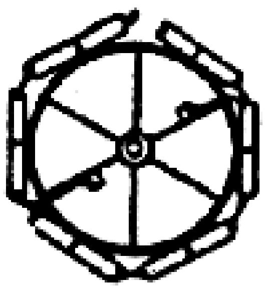


Triangles Fig. 50

In making the larger triangles (a) take 3 small choked cases ½" diameter. Ram two of them with triangle composition to within ¾" of the end; then stop ends with ½" of same composition moistened with dextrine water and ram tight with solid rammer. The third case should be closed with clay. Now cut papering 2" longer than the case and cover in the regular way. Into the choked end after priming, twist a piece of match 1½" long, except the first one where a shorter piece will suffice. Fasten them to block as described above, first the one with clayed end, then one with both ends open and finally the one with short match. Insert match of third case into nosing of second one and match of second case into the first and secure the joints with pasted tissue paper.

VERTICAL WHEELS.

Made by fastening 4 to 8 driving cases to a wooden wheel made for this purpose. The cases are usually ½" to ¾" in inside diameter, either choked or rammed on a nipple with clay. They are papered and matched the same as for triangles except that the connecting matches should be papered as the distance between cases is greater than in the triangles. A little gum on the side of case where it touches the rim of wheel will hold it more securely than wire alone. The wood wheels for these may be obtained in North Weare, N. H.



Vertical Wheel.
Fig. 51.

SAXONS.

Saxon Fig. 52.

Ram two cases ½" to ¾" inside diameter with a strong composition, closing both ends with clay and gluing them to a block as shown. Holes are bored ¼" diameter and just through case, as near to clayed ends as possible and at right angles with the nail hole in center of block on which saxon will revolve. These holes must, of course be on oposite sides. A piece of match is fitted into one of these holes and secured with pasted paper while another hole is bored into bottom of case but on side opposite to that of first hole. From this hole a piece of match is led to hole in second case; fastened with a tack and well secured with pasted strip. (Fig. 52)

Colored pots are attached to wheels and saxons greatly enhancing their beauty, by ramming light cases ¾" diameter and 2" long, with torch composition. They are fastened to the piece as shown and usually matched to the second case. Also, on larger vertical wheels the composition of the various drivers is varied so as to increase their effect as burning proceeds. The first case is charged with plain driving composition; the second with steel filings added; the third with granite stars etc.

Triangle Composition

Saltpeter	18	12
Sulphur	2	8
Mixed charcoal	5	5
Rifle powder FFF	12	12

Wheel Cases (Drivers)

Meal powder	8	3
Saltpeter	3	2
Sulphur	1	1
Mixed charcoal	1	1
F rifle powder	1	
Lampblack	½	
Steel filings ad. lib.		

Saxons

Meal powder	4
Sulphur	2
Saltpeter	2
Mixed charcoal	1

STARS.

This subject covers probably the most comprehensive division of the art of fireworks making. Besides the endless variety of colors, effects etc. we have the cut star, box star, pumped star, candle star etc. Nearly all stars are made by dampening the composition with water (if composition contains dextrine) or alcohol (if it contains shellac) and pressing the caked mass into little cubes, cylinders etc. by the various devices to be described.

CUT STARS.

These are the simplest form of stars in use. Secure some oak wood strips 1" wide and ⅜" thick, dressed, and from these make a frame about 12" wide, 18" long and ⅜" high inside measurements, when lying down. The corners should be secured by halved joints, glued and fastened with small wire nails, clinched. Also provide a rolling pin about 2" diameter and 15" long. Now take any one of the formulas given for cut or pumped stars and moisten it rather more than for use with pump. The most convienent way to moisten any composition is to have a large dish pan or small wooden tub into which the composition is put while water is added little by little, working it in by rubbing the dampened portions between the hands until it is evenly moistened and a handful, firmly squeezed retains its shape.

Lay a piece of stiff cardboard on a marble slab, dust it with dry composition and lay on it the above mentioned wood frame. Fill frame heapingly with the dampened composition and press it down firmly with the rolling pin, leveling it off with a sliding motion so it is flush with the top of frame. Now, with a ruler and a table knife score the composition in each direction at a distance of ⅜" apart, so as to cut it into cubes. This is facilitated if the frame has been previously marked at ⅜" intervals. Make a cut around the inside edge of the frame so as to loosen the stars and carefully remove it. The batch may now be placed in the sun to dry. When throroughly dry the cubes may be broken apart for use.

On account of the ease with which these stars ignite, owing to their sharp corners, they are particularly adapted to rockets, small shells etc. where smooth stars are liable to miss fire. If larger sized stars are desired a frame of ½" material or thicker may be used.

JAPANESE STARS.

This beautiful effect is made somewhat similar to the above. The great difference between the bulky lampblack and the compact potash makes it quite difficult to mix them thoroughly and this is particularly necessary to, obtain good results. Furthermore it is hard to get lampblack to take up water. It is therefore necessary first to moisten it with alcohol when it will take the water more readily. The method which I have followed with best success is as follows;

	#1	#2
Lampblack	12 ozs.	6 ozs.
Potassium chlorate	8 "	4 "
Saltpeter	1 "	
Water	18 "	9 "
Alcohol	4 "	2 "
Dextrine	1 "	
Gum arabic		½ "

Mix the dextrine and saltpeter (formula 1) well together and add sufficient water to make a gummy liquid. Boil the balance of the water and add the chlorate of potassium to it. Put the lampblack in a large pan and pour the alcohol over it working it in as well as possible. Now add the chlorate of potassium disolved in the hot water and stir with a stick until cool enough for the hands. Lastly add the dextrine and saltpeter. Remember that you cannot mix it too well and the effect will be in proportion to the evenness with which this has been done.

Take some pieces of light canvas or ticking about 18" square and put one or two handsfull of composition onto it; spread it about an inch thick in center of cloth, folding same over it, and place under a strong press of some kind. Fold up another cloth of composition in a similar manner and place on top of first. Repeat until 4 or 5 cloths are under press and screw up as tightly as possible and until surplus water runs out freely. Open press, remove cakes from cloths, dry for about two weeks and break into pieces about ½" square. It is important that the lampblack is perfectly dry and free from oil to get the best results and it is sometimes necessary to pack a jar or crucible with it and heat in a bright fire until all volatile impurities are expelled. You will then have one of the most beautiful effects of the entire fireworks art.

In recipe #2 the potash and lampblack are sifted together several times; add alcohol; then water in which gum has been disolved and proceed as in recipe #1|

BOX STARS.

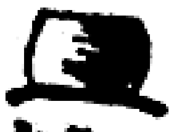
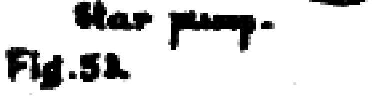


fig 54

Where the best and handsomest effects are required this form of star is undoubtedly the most adaptable to the purpose. First, they burn much longer than others; second, they are less liable to go blind and furthermore they will stand more blowing from a shell than any other form of star. (Fig. 54).

Make some light cases of about four thicknesses of stout manilla paper 6" to 12" long on a ½" former. Cut with a scissors into ½" lengths. Cut some thin match into lengths of an inch or a little over. Pass a piece of match through one of the little pieces of case or "pill box", bend the ends slightly around the edges as shown in illustration and dip it into a pan of composition previously dampened as described before. Then with the first and second fingers of the right hand press the composition into it as firmly as possible until it will hold no more. Dry in the sun for two or three days.

PUMPED STARS.



Star pump.

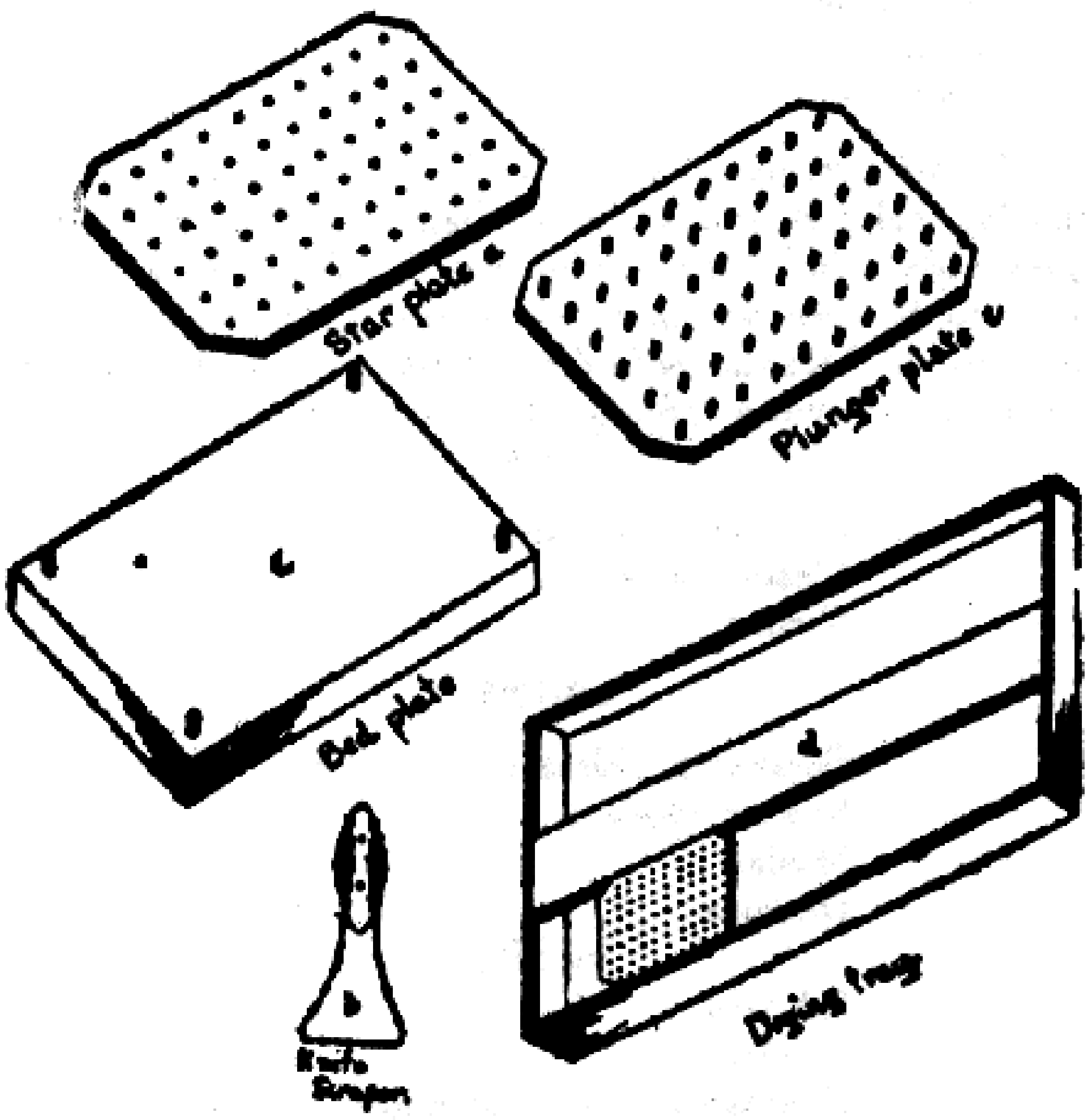
Fig.52

These are used more than any other form of star on account of their regularity and the ease and speed with which they can be made, being even more quickly made than cut stars where the proper appliances are at hand. Where only a few are required, a hand pump (Fig. 53) will do very good work. All that is necessary is to draw up the plunger, press the pump into damp composition until filled and by pressing the plunger while holding the tube, a star is ejected. When they are required in large quantities, however, star plates are necessary. With these 200 or 300 stars are made almost as quickly as one by hand pump. A good idea may be obtained by reference to (Fig. 55). The standard sizes of stars are about as follows:

#1	#2	#3	#4
¼" diam.	5/16" diam.	⅜" diam.	7/16" diam.
⅜" long	7/16" long	½" long	9/16" long

Consequently the plate for making a #1 star must be ⅜" thick and have holes ¼" diameter (a). The others, in same proportion. The plungers on plunger plate (c) must be somewhat smaller in diameter and slightly longer than the holes in star plate so they will move freely and force the stars completely out. The plates are about 5½" x 7½" square. Trays for holding the stars while drying (d) should have the bottoms made of brass wire netting so as to permit free circulation of air through the stars, enabling them to dry in a few hours. The center strip as well as the sides of the tray on top should be rabbeted so as to hold the star plate while stars are being pumped.

Star plate assembly Fig. 55



In order to make stars with a star plate, moiste batch of composition in a dish pan with water as heretofore described, and empty same on a rather high work table previously covered with a square yard of rubber cloth. Press the plate (a) into same until the composition comes up through the holes. Then with the scraper knife (b) work more composition down into the holes until they appear full. Scrape off all surplus composition and remove to the iron bed plate (c) putting down the side previously up and press more composition in with the scraper. When all the holes are well filled scrape off surplus thoroughly, place in rabbet of tray and with plunger plate pump out the stars. Care must be taken to have right side of the plate up when pumping or plungers will not fit holes. If the plate begins to work badly on account of the composition drying on plungers same must be washed before using again. The proper dampness for composition can only be ascertained by practice. If too dry stars will crumble. If too wet they will not ignite freely. The holes in the star plate as well as the plungers may be much closer together than shown in cut.

Formulas for Cut, Pumped or Candle Stars.

WHITE STARS.

Saltpeter	50	54
Sulphur	15	15
Red arsenic	15	9
Dextrine	3	3
Black antimony		15
Red lead		6
Shellac		1

RED STARS.

Chlorate potassium	6	24
Shellac or red gum	1	3
Fine charcoal	2	4
Carbonate strontia		4
Nitrate strontia	6	
Dextrine	½	1½

BLUE STARS.

Chlorate potassium	24
Paris green	9
Nitrate Baryta	8
Shellac	5
Dextrine	1½

GREEN STARS.

Chlorate potassium	6
Nitrate Baryta	6
Fine charcoal	2
Shellac or KD gum	1
Dextrine	½
Calomel ad lib.	½

YELLOW STARS.

Chlorate potassium	16	16
Shellac or red gum	3	3
Fine charcoal	4	1
Nitrate Baryta	6	
Oxalate soda	1	7
Dextrine	1½	1

EXHIBITION PUMPED STARS.

GREEN (not for shells)

Barium chlorate	12
Potassium chlorate	8
Calomel	6
Shellac	2
Picric acid	2
Lampblack	1½
Dextrine	½

RED

(for hand pump; not suitable for Shells).

Nitrate strontia	8	
Chlorate potassium	4	10
Picric acid	1½	1½
Shellac	1½	¼
Fine charcoal	1	1
Dextrine	½	¼
Strontium carbonate		3

Exhibition Blue Stars, pumped.

Potassium chlorate	48	18	16
Calomel	18	6	12
Black oxide copper	6		
Asphaltum	6		
Dextrine	1¼	1	
Paris green		4	
Stearine		2	
Copper ammonium chloride			4
Lactose			6
			*

***moisten with shellac solution**

Silver Comet Star

Meal powder	22
Antimony Sulphide	5
Aluminum, fine	1½
Aluminum, flitter	1½
Dextrin	2

Gold Comet Star

Meal powder	16	16	24
Aluminum, fine	2½	1¼	3
Aluminum, flitter		¾	
Sugar of milk	½		
Antimony		3	3
Sodium oxalate		2	4
Dextrin		1½	1

BOX STARS.

Red

Strontium nitrate	3
Potassium chlorate	3
Shellac	1
Dextrine	¼

Green

Barium nitrate	3	
Potassium chlorate	4	
Shellac	1	1
Dextrine	¼	
Barium chlorate		9

Blue

Paris green			25
Potassium chlorate	10		50
Potassium perchlorate		24	
Copper Sulphate	3		
Copper ammonium chloride		6	
Shellac	2		
Stearine		2	8
Asphaltum		1	
Dextrine	½		5
Calomel	2		

In first recipe, mix thoroughly the copper sulphate, shellac, calomel and dextrine; then add chlorate potash, previously sifted alone. This star is only suitable where it is to be used within a few weeks. In second formula rub up the stearine with the copper ammonium chloride in a mortar before adding other ingredients.

Pink

Potassium perchlorate	16
Plaster paris	4
Shellac	3

Yellow

Potassium chlorate	4
Sodium oxalate	2
Shellac	1
Dextrine	¼

White

Saltpeter	7
Sulphur	2
Powdered metal antimony	1½
Dextrine	¼

Purple

Potassium chlorate	18
Blk. oxid copper	1
Calomel	6
Strontium nitrate	1
Dextrine	¼

LAMPBLACK STAR.

Meal powder	7
Lampblack	3
Black antimony	1
Dextrine	¼

Moisten with water; press into cakes, dry for one week and break into pieces about ¾" square.

SILVER SHOWER.

Saltpeter	50	18
Sulphur	15	6
Red arsenic	15	
Charcoal	10	⅛
Dextrine	3	
Black antimony		6
Lampblack		1

Moisten with water.

GOLDEN STREAMERS.

Saltpeter	8	8	25
Oxalate sodium	4		
Sulphur	2		
Charcoal	½	4	7
Dextrine	½		1
Shellac			1
Lampblack		3	
Black antimony		1	

STEEL STARS.

Saltpeter	8
*Steel filings	2
Meal powder	1
Charcoal	1
Dextrine	¼

(*treated with parafine)

Moisten with water.

YELLOW TWINKLERS.

Potassium chlorate	8
Lampblack	12
Stearine	1½
Saltpeter	1

Moisten with alcohol and shellac. Pump with hand pump

ELECTRIC SPREADER STARS.

The effect of these stars is quite suprising. A small pellet, no larger than a pea will spatter over an area of 15 feet when lighted. To make good electric spreader stars requires considerable care and judgement as dampening too much or too little greatly reduces their effectiveness.

Zinc dust	36
Potassium chlorate	7½
Granulated coal	6
Potassium bichromate	6
Dextrine	1

Mix thoroughly all but the charcoal and dampen until quite wet. Then add coal and mix again and pump with hand pump. Coal must be all coarse from which the fine has been sifted.

GRANITE STARS.

Saltpeter	14
Zinc dust	40
Fine charcoal	7
Sulphur	2½
Dextrine	1

For shells and rockets, this makes a very good substitute for electric spreader stars while being cheaper and safer to handle. It is moistened until quite wet, pressed into cakes ⅜" thick, cut into squares ⅜" each way, thoroughly dried and broken apart.

GOLD & SILVER RAIN. (cut stars)

Meal powder	16		4
Saltpeter	10	1	1
Sulphur	10	1	
Fine charcoal	4	1	2
Lampblack	2		
Red arsenic	1		
Shellac	1		
Dextrine	1		
Lead nitrate		3	

Moisten with water and cut into squares ¼" each way.

ALUMINUM STARS. (box-stars only)

Potassium chlorate		8
Potassium perchlorate	8	
Aluminum powd. medium	4	4
Shellac		1
Lycopodium	1	

Moisten with shellac solution and form into box stars ⅛" long, ¾" diameter.

MAGNESIUM STARS.

Saltpeter	5
Magnesium powder	2

Moisten with linseed oil. Owing to its high cost and unstability magnesium has been almost entirely replaced by aluminum.

COMETS.

These are large stars about 1½" diameter fired from small mortars of paper. In their simplest form they are just large pumped stars. If the gun is 10" long a piece of quickmatch 16" long is bared at one end about 1" and at the other 5". Lay it along side the comet star so the 1" bared end can be bent over the bottom. Then paste a strip of paper 4" wide and 10" long and roll this around the star over the match with the same amount projecting on each side. When dry gather the upper extension around the match with a string and into the lower projection or bag put a half teaspoonful of coarse grain powder and secure with a string also. Now drop this in the gun and it is ready for use. Handsome effects are obtained by making half of the star of red star composition and the other half of streamer composition.

A more ambitious form of comet is illustrated in Fig. 56. This is rammed into a case as shown, while the upper half, separated from the lower portion by a diaphragm of clay with small connecting orifice, is filled with small stars and blowing charge. At the end of its flight the stars are discharged with fine effect.

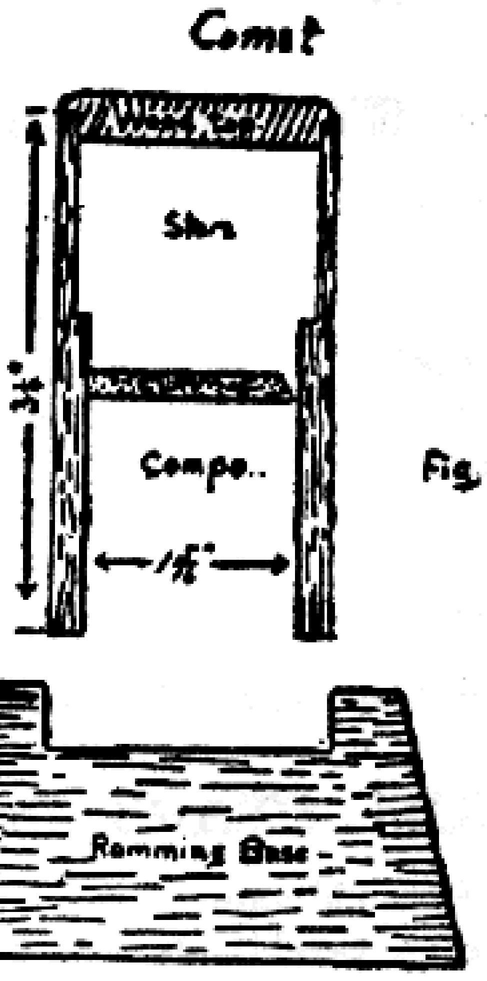


Fig. 56

AEROLITES.

These are made by placing a comet star at the bottom of a short gun with blowing charge but no match. Over the star is placed 2" of candle composition and over this 1" of bengal fire.

COMET STAR COMPOSITION.

Saltpeter	6	
Meal powder	6	3
Sulphur	1	
Fine charcoal	3	1
Powdered antimony	3	1
Lampblack		2

LANCE WORK.

This is a division of pyrotechny which consists of reproducing with colored lights various designs, portraits, lettering etc. after the design is sketched on the floor as described under "Designing".

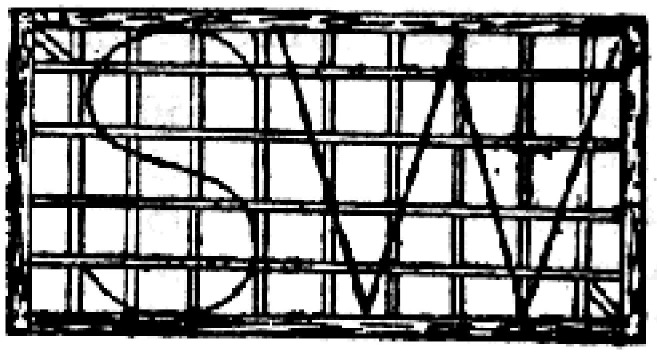


Fig. 57

A number of frames are made, 5' wide and 10' long, of light lumber ½" x 2" for the outside strips and ½" x 1" for the center ones, spaced 1 foot apart each way with a brace in the two corners as shown in (Fig. 57). These are laid over the design on the floor and secured so they do not shift until completed and the picture etc. transfered to the frames with bamboo for the curves and light strips of wood for the straight lines a and b Fig. 58.

When this has been completed frames should be numbered, begining at left hand upper corner of first frame and numbering each consecutively to assist in getting them in their proper places when erecting to be burned.

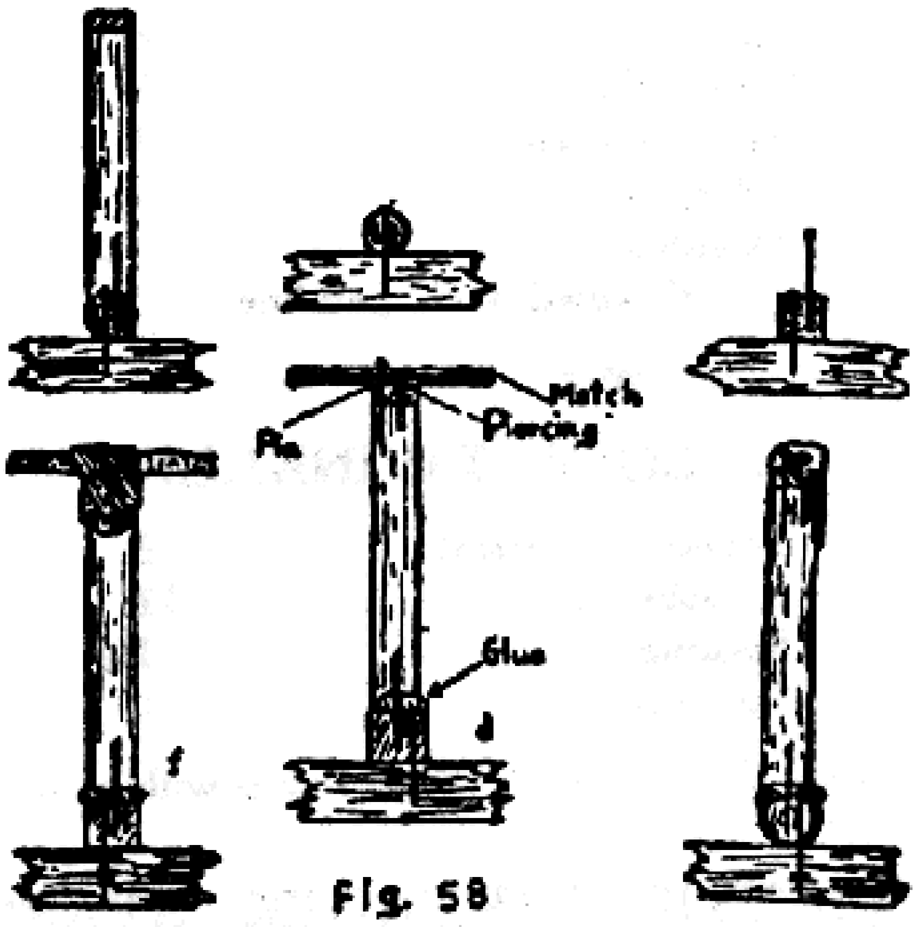


Fig. 58

The frames are now ready for attaching the lances. This is done by driving a 1¼" wire nail to a depth of half an inch, (b) at intervals of 2½" in curves and 3 to 4" on straight lines all over the design. Be sure to see that there is always a nail at every point where two lines intersect. Now with a nipper cut off the heads of the nails, holding the nipper at an angle with the nail so that the place where the head has been cut off will have a sharp point instead of being cut off square across.

The frames are now ready for the lances. When it has been decided what colors are to be used for the various parts of the design, take a handful of lances of the desired color and dip their bottoms into glue to a depth of about ⅛" and press one onto each of the nails until they are attached firmly to the cane or sticks forming design, (c) (Fig. 58).

When glue has hardened frame is ready for matching. Take a length of quickmatch and, begining at the upper end of frame pin it from one lance to another until entire frame is covered, following the outline of design as much as possible, (f) (Fig. 58). When the end of a length of match is reached splice another to it by baring about 3" of the new length and slipping this bare end into the pipe of the preceeding length; securing by tying and pasting joint.

Leave an end of match about 2' long projecting from the lower right hand corner of each frame so it can be connected to the one next to it when erecting. Also on one of the bottom frames leave a leader 10 to 20 feet long, of match, to light piece by when it has been erected. Now with a three cornered awl make a hole ½" deep through the match pipe and into the priming of each of the lances on the frame, (d) (Fig. 58). Then take strips of tissue paper ½" wide and 3" long; paste a number of them onto a light board and working along from lance to lance secure the match to top as shown at Fig. 58. Sometimes where it is desired to rush a job to be burned same day at point where it is made, the lances are secured by simply bending a pasted strip an inch wide over top of lance as shown at a, b, Fig. 59.

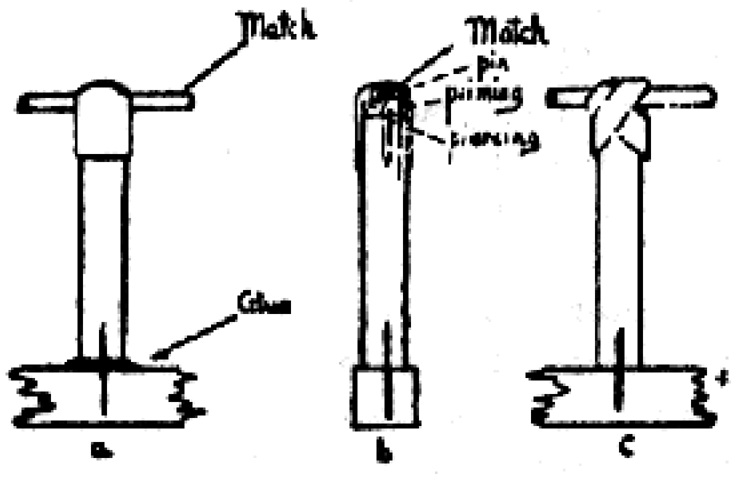


Fig. 59

The completed frames may now be crated into lots of four, with ½" x 4" strips arranged to hold them apart, for convienence in transportation.

LANCES.

These are small paper tubes from ¼" to ⅜" diameter 2" to 3½" long filled with composition burning different colors with a duration of one minute and used for producing the different designs used in fireworks exhibitions, such as portraits, mottoes etc. The cases are rolled and rammed with funnel and rod, as previously described.

Some lance compositions are so light as to be difficult to ram. These should be slightly dampened first. Blue lances made with paris green and white ones using realgar are frequently used without priming as they ignite very easily.

A good lance should burn clear for one minute, without flaring or clogging up. All colors should burn of about the same duration. If a lance burns to one side it is often because the composition is not well mixed or because there is more paper on one side than on the other. They should have about three turns of paper all around.

LANCE COMPOSITIONS.

Red Lances.

Potassium chlorate	16	16
Strontium nitrate	3	
Strontium carbonate		3
Shellac	3	2
Lampblack	⅛	¼

Green Lances.

Potassium chlorate	7	16	
Barium nitrate	7	4	4
Barium chlorate			5
Shellac	2	4	1
Calomel		3	2
Lampblack		⅛	
Picric acid		1	

White Lances.

Saltpeter	9	14	5	8
Sulphur	1	4	2	2
Antimony sulphide	2			
Antimony metalic		3	1	
Meal powder			1	
Red arsenic				1

Blue Lances.

Potassium chlorate	20	16	12	
Potassium perchlorate				24
Paris green		5		
*Copper sulphate	6			
Copper ammonium sulphate			3	
Copper ammonium chloride				6
Shellac	4		1	
Stearine		1½	½	2
Calomel	4	3	3	
Dextrine	1			
Asphaltum				1

*See directions under box stars for using this.

Yellow Lances.

Potassium chlorate	16	4	4
Sodium oxalate	2	2	2
Shellac	3	1	1
Charcoal	½		
Barium nitrate			1

For amber and purple lances the recipes given under TORCHES may be used to advantage.

BOMBSHELLS.

These represent the highest developement of the pyrotechnical art and require great patience and skill for their successful production. The most wonderful effects are produced by the Japanese while the finest color effects are made by the Europeans and Americans. Shells are made in several forms though round is the most popular. Cylindrical or canister shells however contain more stars etc. and in the more complicated effects it is sometimes necessary to attach a canister to the round shell to contain the parachute etc. (Fig. 64).

Shells are all fired from mortars, the smaller ones made of paper, up to about 3" diameter and the larger ones of wood, copper and iron. The smallest shells with which we have to deal are the

FLORAL SHELLS.

	#1	#2	#3
Diameter	2-5/16"	2-7/16"	3-3/16"
Height	9"	11"	13"

The shells are made of hollow wooden balls which can be turned out by any wood turner. They are made in halves, usually with a rabbet to insure a close fit. Through one half, drill a hole just the size to snugly fit a piece of ordinary blasting fuse, 1¼" long. Glue the fuse on the inside as well as on the outside of the shell case. Now fill each half with stars to which add a teaspoonful of shell blowing powder, glue the edges of each half, clap them together and when dry paste a strip of paper around where the two halves join. Prime the ends of the fuse which should project through the shell about ¼", bend a piece of naked match, about 8" long, around the shell so that the middle of it passes over the fuse, tacking the ends to other half of shell, so that they will stick over about 2". Set it now on the floral shell bottom as shown at Fig. 60 into which has been previously put an even teaspoonful (for the #1, larger sizes in proportion) of F grain powder, and secure with a strip of pasted paper. When dry, slip over the paper mortar, having previously well glued the bottom. Measure distance from top of mortar to top of shell inside and mark same on outside. Punch hole through same at this point; fit on a top and secure. Now take a roman candle a little longer than the mortar; punch a hole in its side near the bottom star; fit in a short piece of piped match bare the other end; slip into hole in mortar, fasten candle to side with wire and floral shell is completed.

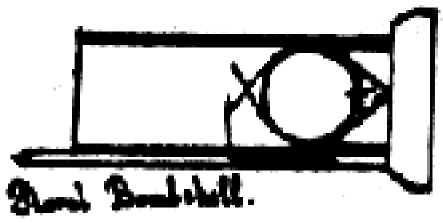


Fig. 60

METEORIC SHELLS.

These are made somewhat differently; ¼ lb. to ½ lb. tin cans being substituted for wood shells. They are filled with stars, colored and Japanese and bursting powder in the same manner as described above. A hole is punched through lid into which fuse is glued. A strip of paper about 3" wider than the length of can and long enough to roll around it six times is pasted all over, the filled can placed on it and rolled up something like a case is rolled. The 1½" projecting over each end is now carefully pressed around the fuse on one side and the can bottom at the other. The shell is allowed to dry for a week before using. The end of fuse is trimmed and primed; a piece of piped match bared at each end is laid against its side, extending 1" beyond fuse at bottom of shell. A nosing 3" wide which secures the match in place is attached to shell and this when dry serves to contain the driving charge of a level teaspoonful of grain powder, after which it is gathered together and tied with twine. A dab of glue on bottom of bag suffices to hold it in bottom of mortar and it is ready for use. (Fig. 61).

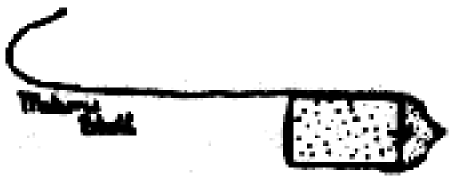


Fig. 61

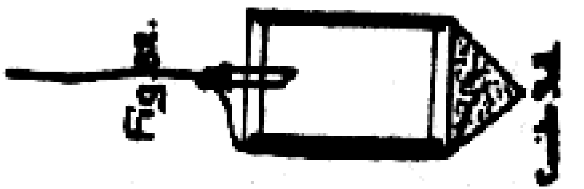
EXHIBITION BOMB SHELLS.

The principal sizes of shells used for this purpose are 4", 6" and 10" diameter. For round shells, after the cases have been made as described under "CASES" the upper halves are bored for the fuses. This may be done with a carpenters brace bit ¾", boring from the inside. Fit the two halves accurately together; bind with a strip of glued cloth and over this two or three layers of paper strips laid on longitudinally; each strip overlapping the one before it by about ¼". If each layer is made of a different length a better finish will be obtained.

When cases have been thoroughly dried fill them with the desired stars through the fuse hole. When they will hold no more add blowing charge. The fuse should now be accurately fitted by cutting around it with a knife ¾" from the top and peeling off a layer or two of paper until it will just enter the hole which has been made in top of shell for it. Glue lower portion well and push into place until shoulder rest squarely against shell case.

Attach a cloth nosing to fuse; bare 1" at the end of a length of match and attach to bottom of shell by a #1 tack; lead match up to fuse bend at right angles to permit of entry into nosing; cut the piping at point of entry and secure with strong cord. The remaining match also serves for lowering shell into mortar, up to 6" sizes. Larger shells must have a heavy cord passed around them for this purpose.

The necessary driving charge having been placed in a paper cone this is attached to bottom of shell when same is completed.



The making of canister shells is so similar that their construction can be readily understood from the sketches (Fig. 62). The heads and bottoms are made of ¾" wood.

Another method of matching shells is to start at the fuse by baring a half inch at the end of a match pipe and pushing this into nosing. Bend match at right angles ½" above nosing and pass under and entirely around shell, coming back again to nosing. Bend once more at right angles and insert bend alongside of where start was made first cutting through match pipe at point of insertion. Gather nosing closely around match and tie tightly as possible. This method gives a somewhat better support to shell when lowering it into mortar. Where the match crosses bottom of shell and enters driving charge be sure to cut piping away for about half an inch, (Fig. 63).

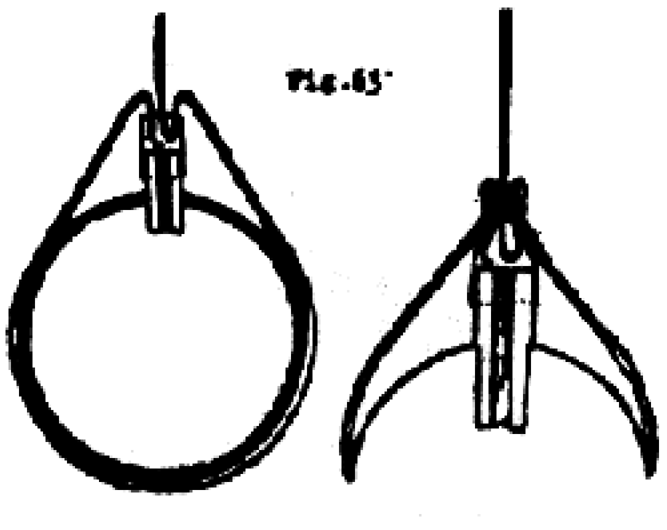


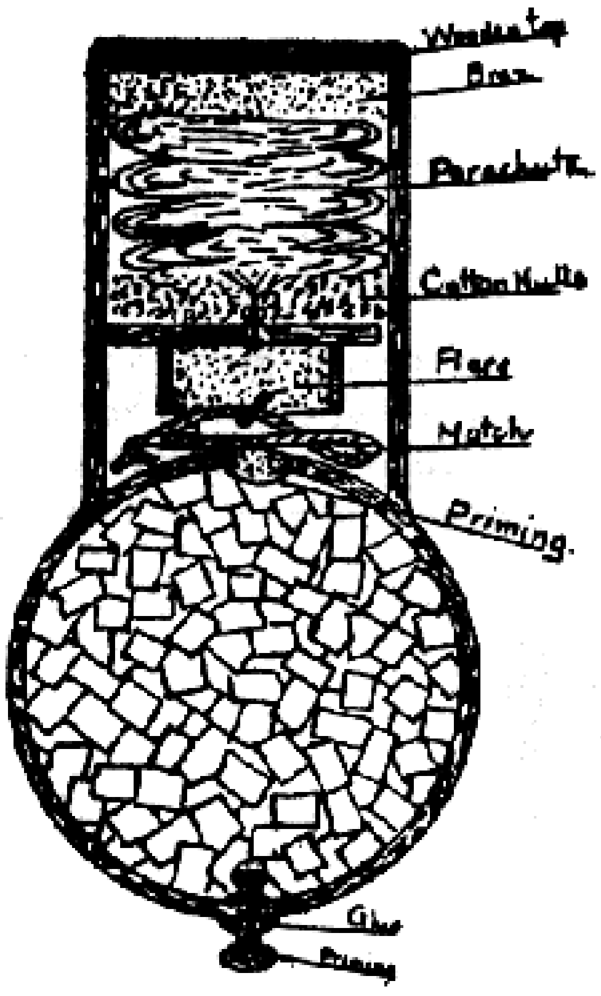
Fig. 63.

Two and three break shells are made by lightly fastening together the desired number of short canister shells with fuses not over ½" long between them. The first shell has regular length fuse. The details can be better understood from drawings than from a description. See Fig. 65.

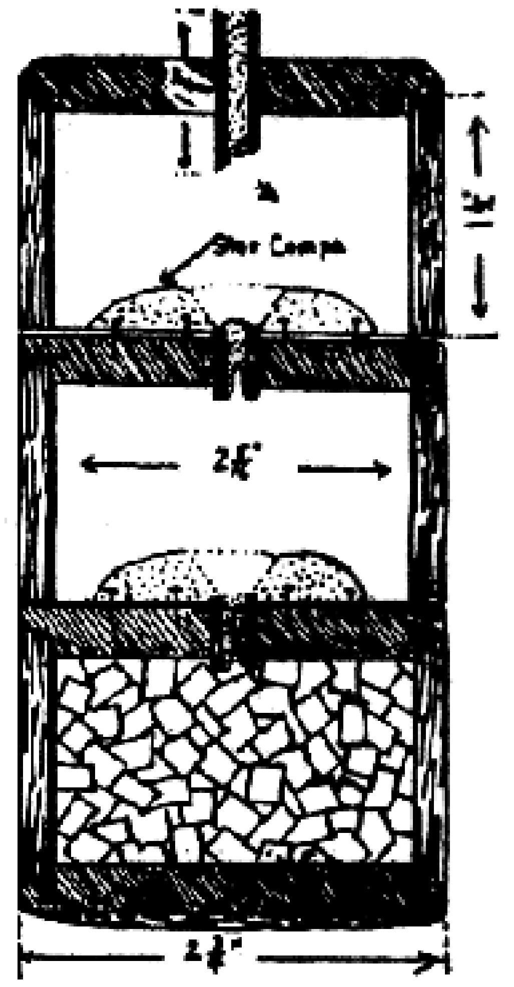
PARACHUTE BEARING SHELLS are also shown in detail, Fig. 64.

SHELL FUSES.

These are best made of hardware paper. Take a rod ⅜" diameter (for a 6" shell) and a sheet of paper 6" wide. Paste it with thick paste all over one side and at once roll it up as tightly as possible until it has an outside diameter of ¾". The length of sheet required is dependent on the thickness of the paper. When a number of these cases are rolled they must be dried in the shade until they are as hard as wood and rattle when struck together.



Parachute Shell. Fig. 64



3 Break Shell. Fig. 65.

Take a rammer 7/16" diameter a light mallet and some fuse composition made as follows:

Meal powder	4
Saltpeter	2
Sulphur	1

Sift and mix three times. Rest a fuse case on a firm block, scoop in a little composition and tap it about ten light blows. Add more composition and ram again, repeating until fuse is filled. The composition in fuse must be as hard as possible when finished, otherwise it will blow through when used in a shell. The fuse may now be cut into the required lengths with a fine toothed hack saw. (Fig. 66).

Length of fuses.	Inside diameter of fuses.
4" shell 1¼"	4" shell 5/16"
6" shell 1⅜"	6" shell ⅜"
10" shell 1½"	10" shell 7/16"

In some cases a hole is drilled into the composition of the fuse on the end in the shell, ¼" deep, so the fire from same is thrown into the shell with more force. In this case allowance must be made when cutting length of fuse.

Shell Blowing Powder may be made of:

Grain powder	1
Meal powder	1
Saltpeter	3
Charcoal	1½
Sulphur	1

The bursting and driving charge for shells is as follows:

Bursting Charge.		Driving Charge.	
4" shell	1¼ oz.	4" shell	1½ oz.
6" shell	5 oz.	6" shell	3½ oz.
10" shell	16 oz.	10" shell	14 oz.

The driving charge should be coarse grain powder; cannon powder is best. An endless variety can be produced with shells some of which follow while the ingenuity of the pyrotechnist will suggest others as he progresses.

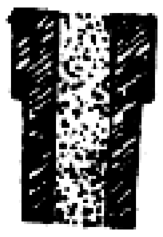


Fig. 66

Solid color shells
Varigated shells
Gold rain shells
Japanese or willow tree shells
Streamer shells
Aluminum shells
*Conch shells
Chain shells
Repeating shells
Maroon or Salute shells
Day shells.

*The Conch Shell consists of a 10" diameter shell packed with three ball roman candles made specially for this purpose. The cases of the candles are made of very strong paper so that they can be thin and no empty portion is left at top and bottom. In addition to the little roman candles, colored stars are added. This makes a very effective shell.

SHELL CONES.
(for holding driving charge)

These are made by cutting out a round piece of good Kraft paper six to twelve inches diameter according to size of shell for which cone is intended. With a scissors make a cut from the edge to the center and twist it around so as to make a bag or cone of two thicknesses, pasting the edges where they meet. Put the driving charge into this and with a little paste attach it to the bottom of shell having previously cut the match piping where it crosses the bottom, so that fire will strike driving charge when shell is lighted.

JAPANESE BOMBSHELLS.
Day and Night

The Japanese have developed this form of pyrotechny to an almost incredible degree of beauty and originality. Some of their shells are marvels of patience, ingenuity and skill.

DAY SHELLS consist of two kinds. First, those containing large figures of birds, animals etc. made of light tissue paper sewed together like a bag and open at the bottom with a row of small weights around the rim of the bottom. The figure is folded into a small compact pile and packed into a cylindrical shell case, somewhat as parachutes are placed in rockets. When they are fired to a height of about 1000 feet the figure is expelled with a light charge and as it falls, the weights cause the bottom to unfold and the inrushing air inflates it. One of their day shells contains about a dozen paper parasols which, of course, are folded when inside the shell case but which by an ingenious construction, open as soon as shell breaks and they float to the ground much as parachutes do. The arrangement is as follows:

The second variety of day shells consists of colosal spiders made of smoke and varicolored clouds which must be seen to be appreciated. They are made by filling a round shell with smoke stars, on top of which is set a canister containing a number of 1½" diameter colored smoke shells and a parachute from which hangs a "smoke dragon".

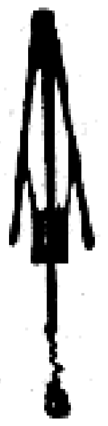


Fig. 66a.

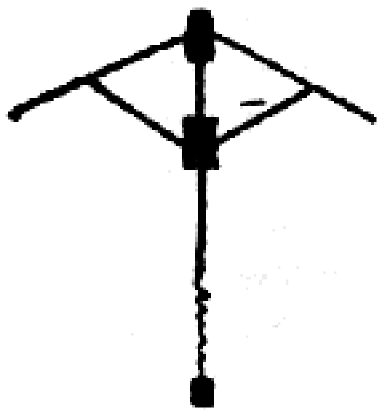


Fig. 66b.

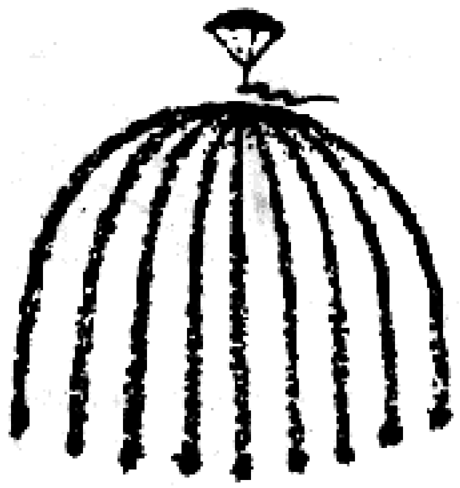


Fig. 66c.

The night shells embrace some 50 or 75 different effects. Up to 40 years ago colors in night shells seem to have been unknown to the Japanese and all their devices consisted of endless varieties of tailed stars, gold and silver rain, willow trees and bright work, each one, more entrancing than the other. Among some of their very unusual effects is a night shell which upon reaching the height of its flight throws out five red paper lanterns with a light burning inside each one. The lanterns when inflated are about two feet in diameter and four feet high. When folded inside the shell they occupy a space about five inches diameter and nine inches long. Another of their original shells breaks with their very round effect but only one half of the circle is filled out with stars while the periphery only, of the other half is outlined with stars as shown below. (Fig. 66d). To secure this effect a wing or tail is attached to the shell which holds it in the required position, relative to the observers at the moment of explosion.

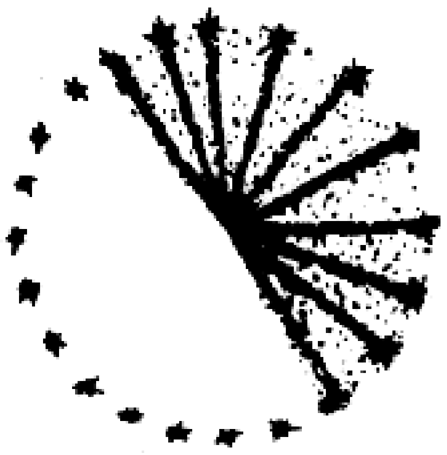


Fig. 66d.

The arrangement of the contents of these shells is shown in the accompanying sketch, (Fig. 67). The inside of the round shell case is scored as shown at (a) and (b) by cutting half way through the paper with a knife in order to cause shell to burst evenly and throw the stars equally in all directions.

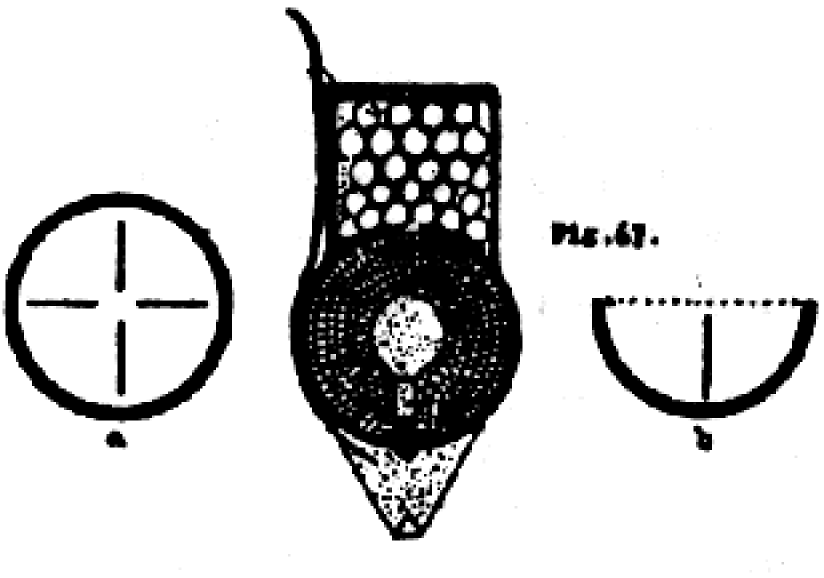
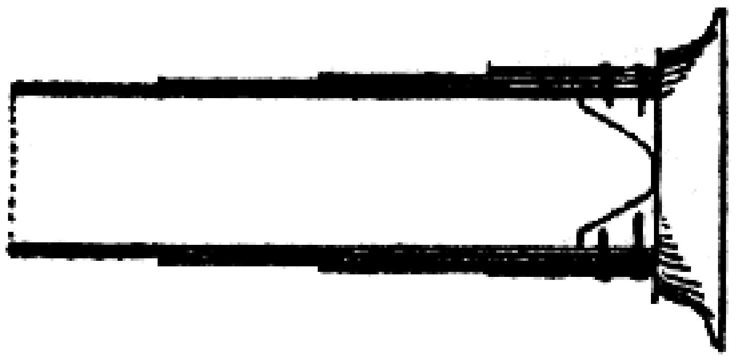


Fig. 67.

Smoke stars are pill boxes ½" diameter and ½" long, closed at one end and over the other end are bent two strips of thin metal (copper or tin) which are secured by a paper fastening so as to restrict the opening to about one third its original size. The stars are charged with the composition shown under "Smoke Stars", the end being well primed over the metal strips. They are then arranged in the round part of shell as shown in Fig. 67. The little smoke shells and parachute are placed in upper or canister portion.

MORTARS.



MORTAR Fig. 68

Mortars for firing pyrotechnical bombshells are made in a variety of different ways. For shells up to 3" in diameter a mortar 12 to 15 inches high, made of a number of turns of good stout paper will serve for perhaps a hundred shots, especially if lined on the inside with a piece of tin or galvanized iron. If a bottom of oak or other hardwood is fitted to it and the barrel tightly wound with marlin, it will be perfectly safe, light and cheap.

For 4" diameter shells and upward mortars of copper tubes, shrunk, one over the other so that there are four thicknesses at the bottom, three for half the length two up to three-quarters of its barrel and one thickness for balance, with a ring at the top make an ideal mortar.

Wrought iron tubes wound with galvanized wire and fitted with cast iron bottoms securely fastened in by machine bolts or rivets make very servicable guns. The bottom should be conical on the inside to accomodate the powder bag of shell. (Fig. 68).

The Japanese used long wooden mortars reinforced with iron bands. These were soaked in water before being used, to swell and tighten them. On account of their length they would throw a shell to a great height with a small driving charge. They should always be buried for half their length in the ground when in use. With these mortars it was customary to pour the driving charge for shells, loosely into the mortar, drop the shell over it and fire by shaking a little dross from a port fire into the mortar. This method is dangerous and is not to be recommended.

Mortars with port holes on side of bottom, like the old style military mortars are sometimes used for day shells. The cartridge of shell is pierced with a priming rod and a piece of bare match inserted through port hole.

BALLOONS.

Secure some good tissue paper 20" x 30" (Foudrinier is best). Paste two sheets together on the 20" ends making a sheet 20" x 60". Split this lengthwise and get a sheet 10" x 60". Make twelve sheets of this size; lay one on top of another and double over the lot longitudinally so as to have pile 5" x 60". Now, with a scissors cut along the unfolded edge as shown in Fig. 69 (a), removing the part shown as shaded. The exact line to cut may be determined by practice until the most satisfactory shape is found when an extra sheet of heavy paper should be cut and reserved as a pattern. Or, the pattern can be made according to instructions given under "Balloon Designing".

Unfold sheets cut as above and lay one on the table before you. On top of this lay another but about ½" nearer to you thus leaving an uncovered edge of the under sheet exposed (b). Apply paste lightly to this edge and lap it over onto the upper sheet in this manner joining the two for their entire length. Make six pairs of sheets like this and then repeat the process with the double sheets until you have three sets of four sheets. Join these as before making the final closing joint likewise. If the top of balloon where the joints meet is not well closed paste a small round piece of paper over all.

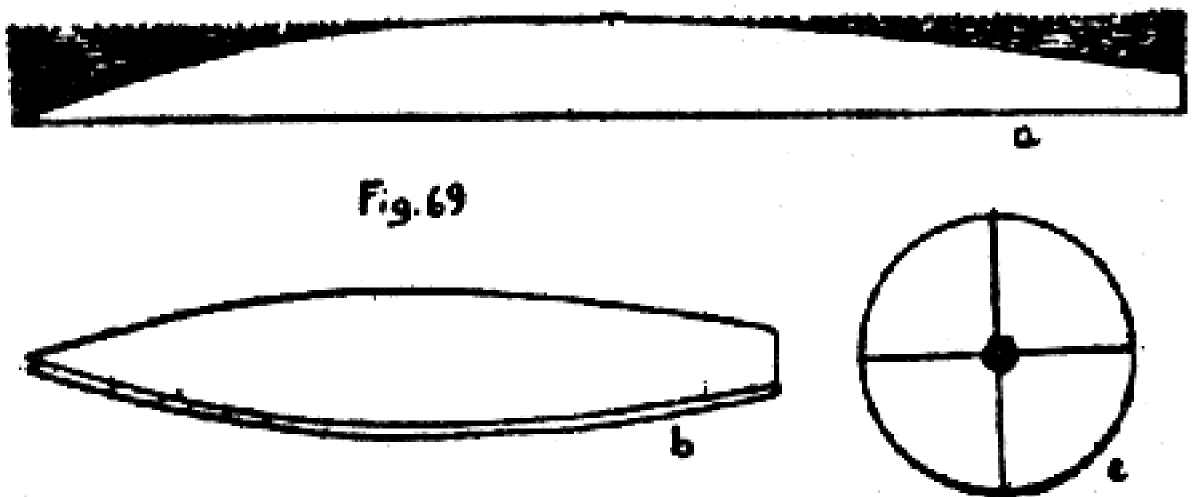


Fig. 69

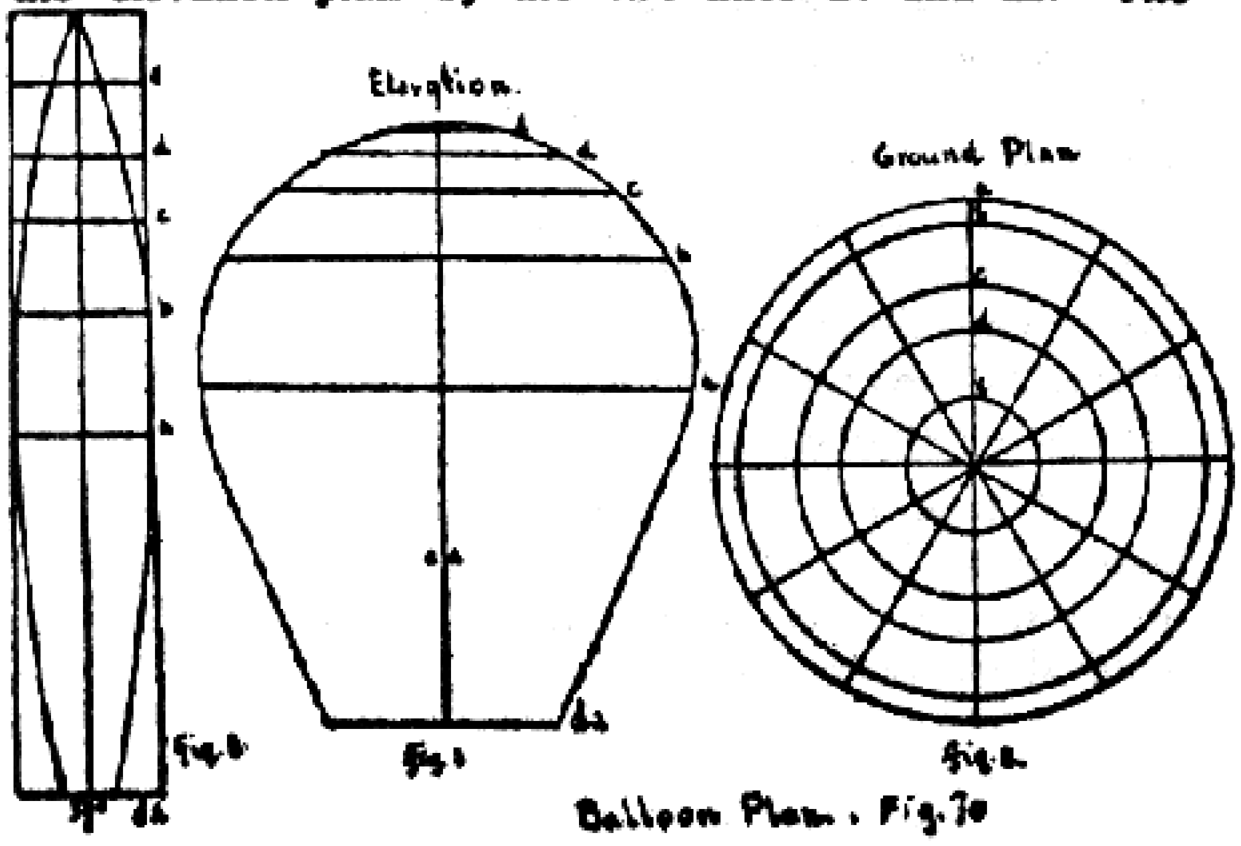
When balloon has dried make a ring of wire, bamboo or rattan for the bottom with cross wires to hold the inflator (c). For a balloon of the above size the ring should be about 15" diameter. In balloons 10 feet or more in height a wire basket is sometimes woven into the center of the ring so that an extra inflator may be added just before releasing balloon when ready to rise.

BALLOON INFLATORS.

These are made in several ways. One consists of a ball of cotton wool which is saturated with alcohol or kerosene oil when balloon is to be inflated. A more convienent inflator may be made by impregnating a ball of excelsior with parafine and fastening it on top of cross wires of balloon ring. This has the advantage of being cleaner and requires nothing further than lighting when balloon is to be raised.

DESIGNING BALLOONS

A balloon five feet high when deflated can be made from twelve pieces of tissue paper cut out of sheets 10" wide and 60" long. To get the proper shape for cutting these sections draw a plan of the desired shape of balloon when finished, somewhat as shown in Fig. 1. Then make a ground plan as shown in Fig. 2. Quarter the elevation plan by the two lines a1 and a2. The lines a1 represent the balloon at its widest point in both plans. Line b in ground plan is obtained by measuring the length of line b in Fig. 1 from central line a2 to the edge of balloon and then taking the same distance from the center of Fig. 2 and making a circle with a pair of compasses at this point. Lines c, d and e are obtained in the same manner.



Balloon Plan. Fig. 70

Now, to make the pattern as shown in Fig. 3 draw a plan of one of the sheets from which the balloons is to be cut using same scale as in Figures 1 and 2. Divide it by a line through its center lengthwise and then locate lines a 1, b 1, c 1, d 1 and e 1 by measuring distance from bottom of balloon to each cross line on Fig. 1 along one edge from d2 to e. It now only remains to locate the points on Fig. 3 for getting proper shape of pattern. To do this take a pair of dividers and measure length on line b 1 from central perpendicular line in Fig. 2 to point where it intersects the next radial line to the right. Divide this distance equally to each side of central line of line bl in Fig. 3. Do the same with lines c, d and e. On a large plan this may be more accurately done with a flexible rule but when using dividers as above a slight allowance must be made for the curvature of the lines on Fig. 2. All that is necessary, now, is to draw an easy line from top to bottom of Fig. 3 as shown. The bottom of 5' balloon should be about 15" diameter. Dividing this by four will give approximately 3¾" for bottom of pattern.

Fireworks Attachments for Balloons.

These make a very pretty addition to a balloon ascension and may be designed in numerous ways as to ingenuity of the pyrotechnist will suggest. A typical attachment is shown in accompanying sketch (Fig. 71).

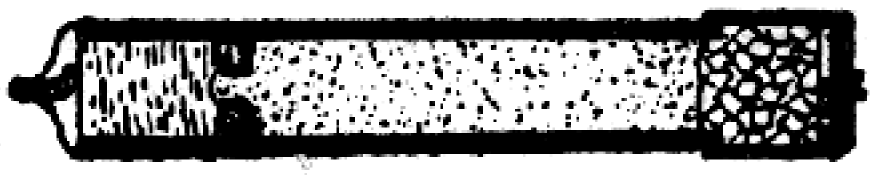


Fig. 71

The lower portion of a gerb is filled with red fire which burns until the balloon reaches the height of several hundred feet; then the gold rain effect of the gerb functions until the heading of stars, serpents etc. is discharged. A vertical wheel suspended from a wire and lighting when balloon is well up in the air makes a very interesting display.

CANNON CRACKERS.

In this item of pyrotechny the history of fireworks in general has been somewhat reversed. While many persons have lost limbs and life in the manufacture of roman candles, rockets etc. on a large scale, comparatively few serious accidents have occured to those using them. On the other hand, though cannon crackers are one of the safest articles in the business to make, they have caused, during their short career the loss of more hands, arms etc. to those firing them than all other kinds of pyrotechnics combined.

The reason is simple. The composition of crackers is only explosive when confined or after the cracker is finished and the explosion of a finished cracker will not ignite others, as is the case with candles etc. where a spark will fire thousands at once. But when crackers are used by the inexperienced it is difficult to determine whether the fuse is lighted or not which often causes the cracker to explode in the hand with disastrous results. Its bloody record has caused a number of states to legislate against its sale in sizes larger than three to four inch. Until a fuse is invented that will be consumed as it burns, this piece of fireworks will be dangerous to handle. The first available record of the manufacture of American Cannon Crackers on a commercial scale was about the year 1880 when Edmund S. Hunt of Weymouth, Mass. devised a very ingenious machine into which was fed empty cases from a hopper while the composition and fuse was inserted and the ends crimped at one operation. Previously only Chinese crackers were used but the increased loudness of the report and the reduced cost of making them soon caused the American article to supplant the imported one in the larger sizes.

With the advent of the Flash Cracker the Chinese have again invaded the American market to a large extent.

The cases for crackers are rolled similar to rocket cases except that paste is used only on the last turn at farthest end of sheet, the body of the case being rolled dry. By this means the cracker is more easily blown into small fragments and the danger of being struck by a large piece of hard case is avoided. The fuse used is the small red cotton untaped fuse made especially for this purpose though most any kind of blasting fuse may be used. A piece from 1½" to 3" long is sufficient according to the length of the cracker.

Various compositions are used, those containing Antimony giving the loudest report while those made with sulphur only, produce less noise. The cases should be filled about one third full of composition to obtain the best results and composition must be loose, not rammed. The addition of charcoal will increase the lightness of the composition and prevent its tendency to pack which lessens the report.

The ends of crackers are stopped in various ways. The best is by means of crimpers which pinch or mash the ends of the case around the fuse at one end and into a bunch or lump at the other. A dab of glue retains the ends in place. Another method is to close the fuse end with clay and the other with a cork. The low grade of corks used for this purpose can be bought for as cheaply as twelve cents per thousand in the small sizes which is less than the cost of plugs of any other sort.

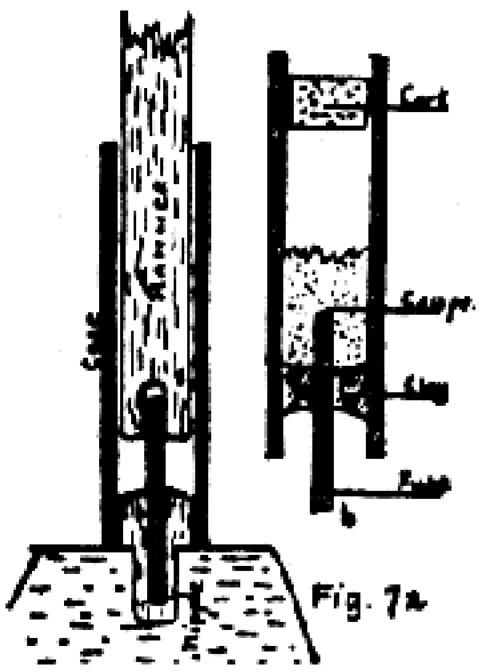


Fig. 72

To make crackers in this manner roll the cases as directed. Make a brass nipple as shown Fig. 72, of the diameter of the cracker desired and about as high from top to shoulder. Drill a hole through the center somewhat larger than the fuse so it will pass easily into it. Also provide a rammer about 6" longer than the cracker and drill a hole into the lower end, somewhat larger than the fuse and ream or countersink it a little. After setting the nipple in a block put a piece of fuse in it, slip a case on, put in enough slightly dampened clay to occupy a half inch when rammed and with a few blows of a mallet set it firmly. You had best now remove the case and with a sharp knife split it open without breaking the clay and see if everything has been operating correctly, that is, if the proper amount of clay has been used and if the fuse projects sufficiently on the inside and has not been mashed into the clay as sometimes happens if the rammer has not been correctly made on the end which rams the clay while the fuse enters hole in same. Unless this has been well done the cracker will fail to explode. When these matters have been properly adjusted proceed with ramming clay in another case and scoop in enough composition (any one from list to follow) to fill case about one third. Then take a cork that will fit pretty snuggly, dip the small end in liquid fish glue and force it in open end of cracker. It is now completed and may be removed from nipple. If too much composition is used the report is weakened; a full case will hardly explode at all.

When crackers are made on a large scale, a block of six dozen nipples is used, six wide and twelve lengthwise, same as for roman candles. The clay and composition can be dropped into lot simultaneously by the use of shifting boards as shown under candle machine. Some manufacturers prefer to use a long nipple and short rammer, reversing the manner of ramming as the cracker is rammed from the fuse end instead of from the cork end. By this means the danger of mashing the fuse into the clay is avoided as the nipple on the inside protects it. But only the clay can be filled into them all at once by this method, as, the composition being loaded from the other end, they must be removed from the spindles before this can be accomplished.

The following are the standard sizes.

Numbers		Length	Bore	No. in box	Boxes in case
1	Salutes	2"	5/16"	100	20
2	"	3"	5/16"	50	25
3	"	3½"	⅜"	15	100
4	Crackers	4"	7/16"	30	20
5	"	5"	½"	20	20
7	"	6½"	⅝"	10	20
9	"	8"	¾"	5	20
10	"	9½"	⅞"	3	20
12	"	10½"	1"	2	20
15	"	13"	1¼"		25 in case.

CANNON CRACKER COMPOSITION

Potass: chlorate	60	6	6
Washed sulphur	23	3	2
Sulphuret antimony	5		
Metalic antimony			1
Charcoal		1	
Saltpeter	12		

If unwashed sulphur is used the report will be considerably louder but the danger is greater. Of the above mixings, the last is about the safest that can be made The first gives the loudest report. Great care must be exercised in mixing the composition for cannon crackers. Each ingredient must be sifted separately and then mixed in a tub with the fingers, preferably gloved, being careful not to scratch the bottom of tub with the nails.

MAROONS.

The name is probably derived from the French word for chestnuts which burst when being roasted, and covers what consists of a case of heavy paper containing an explosive charge which when ignited produces a loud report. Aerial Maroons are simply the same article arranged to explode in mid-air when fired like a shell.

FLASH CRACKERS.

This interesting addition to pyrotechny is one of the results of the advent of aluminum. The following composition may be used both for flash crackers and maroon shells.

	#1	#2	#3
Potass: perchlorate		50	30
Potass: chlorate	6		
Washed sulphur	3	25	30
Pyro aluminum	1	25	40
Charcoal	1		

Mix thoroughly the sulphur, coal and aluminum; then add the chlorate potass; previously sifted by itself; mixing by rolling the ingredients back and forth on a piece of paper and avoiding friction of any kind.

Prepare a block c Fig. 73 by boring several holes as shown, 7/16" diameter and 1" deep. Also a nipple ⅜" diameter fitted into a handle b and some pieces of strong light paper 2½" square a. Take a piece of paper in one hand and with the nipple in the other, press the paper around it so as to form a little cup which is now inserted in the hole in block pressing down until the flange of the nipple spreads the upper edges of the paper. Remove the nipple and put into the paper cup formed, enough composition to half fill it. Insert a piece of match three inches long; draw the paper around the match and secure tightly with two half hitches of linen twine. Remove from block, smear a little gum on one side and push into a cracker case (d) ½" diameter and 3" long. It is not necessary to close the ends of flash crackers as the report is just as loud when they are left open.

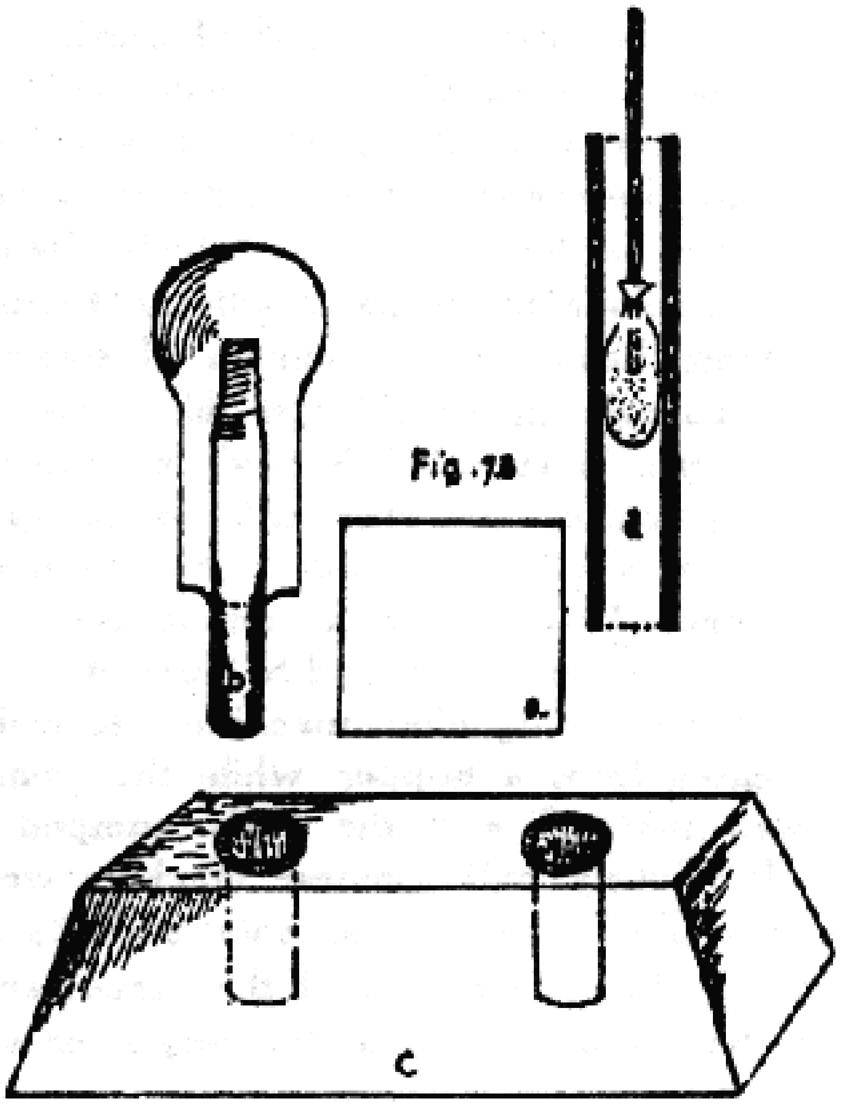


Fig. 73

Composition #2 and #3 are much the safest and should be used by any but those very familiar with this class of work but the ends of the cracker must be tightly closed to secure a loud report as directed for cannon crackers. Also the sulphur in these mixings should not be washed.

TORPEDOES.

By this name is understood the toy torpedoes used by children, which detonate when thrown on the ground. I believe that these were first made by the French under the name of "Pois fulminant" (mad peas), but the so called Jap. or cap torpedoes, which constitute far the largest part of those used today, as nearly as I can find out are an American invention.

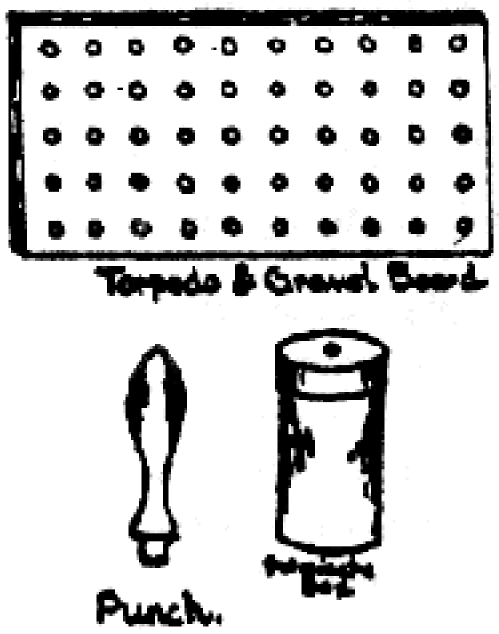
SILVER TORPEDOES.

Fulminate of Silver.

The fulminate is prepared by taking 8 ozs. of C. P.

Nitric acid (42%) and adding gradually, stirring constantly with a glass rod, 2 ozs. water. Into this put a silver dollar or 1 oz. of bar silver. Warm slightly until a brisk reaction takes place. When the silver is completely dissolved allow to cool for three minutes. Then add 16 ozs. pure alcohol. Add it all at once and quickly and be sure that the vessel containing the solution of silver is at least four times as large as the amount contained for a violent effervesence will take place. After it subsides add three ounces more alcohol. Let stand for a quarter to one half hour when a white crystaline precipitate will be formed on the bottom of vessel which is the fulminate and may be collected on a filter and dried in a shady place. A candy jar may be used for making the fulminate but a glass beaker is far preferable.

The utmost care must be excercised in handling the dry powder as the slightest concussion will explode the entire lot with terrific violence. A wooden spoon should be used for removing it from the filter and it should be handled as little as possible and in the smallest practicable quantities. Procure a round paper box from a drug store, one inch in diameter and three inches high. Make a small hole 1/16" in diameter through the cover and fill it about half full of dry fulminate. Now take a board 10" wide and 20" long, ⅜" thick and with a ¾" bit bore 50 holes through it, (5 rows, 10 to a row). This is the torpedo board. Then take a similar board and with a ½" bit bore the same number of holes in the same position, into it but not quite through. This is the gravel board. A punch will now be required as shown in Fig. 74. a, the nipple being ⅝" diameter and ¾" long. Get some of the best grade tissue paper and cut it into pieces two inches square. Take a bunch of them in the left hand. Place one over each hole in the torpedo board, at the same time forcing it in the hole with the puncher so as to make a little bag. When the board is filled with paper dip the gravel board into a box filled with gravel, tilting the board so the surplus will run off and the holes will be just filled. Then reverse the board containing the papers and place it over the board of gravel. Hold tightly together and turn both boards together upside down and the gravel will be emptied into the torpedo board all at once. Remove the now empty gravel board and with the fulminate box shake a little of the powder into each little bag of gravel just as you would shake salt from a salt seller. Only a very little is required. Now dip the tips of the thumb and forefinger into paste and with the finger tips of both hands gather up the edges of the paper, bunch them together and by giving a few twists the torpedo is finished. Care must be taken not to twist too tightly as the torpedo is likely to explode in the fingers.



Silver Torpedoes

Fig. 74.a

JAPANESE OR CAP TORPEDOES.

These, while considerably safer than the silver torpedoes to make and handle require to be struck with much more force in order to cause them to explode. First we must proceed to make the caps. (Fig. 75).

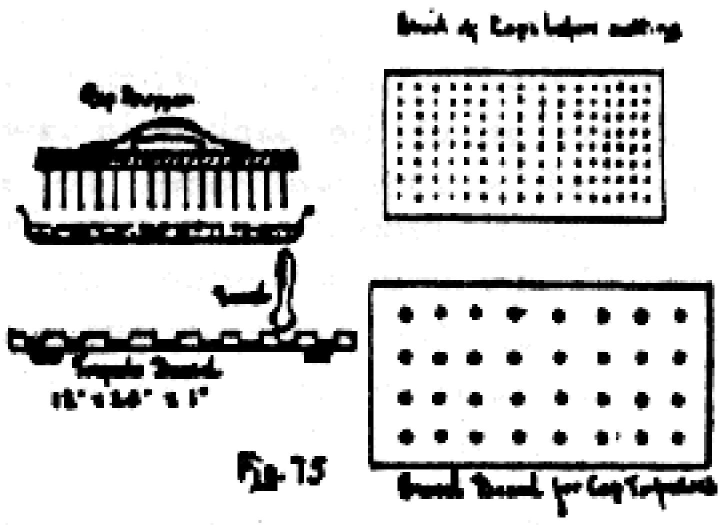


Fig. 75

There are required a pan 2" deep, 8" wide and 10" long, a number of pieces of blanket 12" squares which must be well dampened before using, and a cap dropper made by driving 150 8 penny nails, for one inch of their length into a wooden block 7" x 9", 1½" thick and fitted with a handle as shown in illustration. The heads of the nails should be well leveled up so that every one touches when dropper stands on a flat surface. Also cut a lot of pieces of poster paper 6" x 8" and place them in two piles on the work table. They are for dropping the caps into. The cap composition is made as follows:

NUMBER ONE.		NUMBER TWO.
Potassium chlorate	5 ozs.	Amorphous phosphorus
Sulphur	¼ "	2 ozs.
Chalk	¼ "	

Sift separately the ingredients of No. 1, mix thoroughly and moisten in a bowl with water to the consistency of porridge. In another bowl moisten the two ounces Amorphous Phosphorus, to the same consistency. Then stir the phosphorus into the bowl containing the other ingredients, with a spoon. When thoroughly mixed pour into the pan previously mentioned.

Take the dropper by the handle and dip it into the pan of composition, remove it and print it lightly onto the top sheet of one of the piles of poster. With a wide brush paste the top sheet on the other pile, all over on one side with thin paste to which a little dextrine has been added and reverse it onto the sheet that has just had the caps dropped on it. Now remove the finished sheet of caps to one of the damp blankets and repeat operation, placing a piece of blanket between each sheet of caps until all the composition is used up after which place a light board on top of the pile of alternate caps and blankets, and on this, a weight allowing it to remain for about an hour, after which remove the blankets and place the pile of caps in a tight box where they cannot become dry.

Now fill the torpedo board as before directed only using a somewhat smaller gravel board. Take-out a few sheets of caps and with a long pair of scissors cut between each row of caps each way so as to separate them. Place one squarely on top of the gravel in each torpedo and taking a handful of gravel, drop a little on top of each cap. They are now ready to be twisted as described for silver torpedoes. When a number have been finished they should be packed in sawdust or rice shells and removed from the workroom. Too many should not be allowed to accumulate in a pile, for when dry, the explosion of one will sometimes fire the entire lot and the flying stones often cause serious injury. Be sure never to allow the caps to become dry while making the torpedoes, or in the storage box.

In making caps, when a batch has been completed, be very careful to wipe up thoroughly every drop or speck that may be spilled, and wash well the pan and dropper etc. as well as the table, shears and brush used and throw away the washings where they will run off.

Japanese torpedoes do not keep much over a year as the phosphorus decomposes and after awhile disappears entirely from the cap. Following are the principal sizes and packings of torpedoes:

SILVER TORPEDOES.

Name	Size paper	Holes torpedo board	No. in box	Boxes in case
Electric	1⅜" sq.	½"	25	50
Giant	3" sq.	1"	10	50

JAPANESE TORPEDOES.

Am. Extras	1⅜"	½"	25	100
Japanese	3"	1"	5	200
Japanese	3"	1"	10	100
Japanese	3"	1"	25	40
Cat Scat	5½"	1½"	10	40
Cannon	7"	2"	10	25

RAILROAD TORPEDOES.

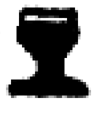


Fig. 74b.

These consist of a 1 oz. tin ointment can containing a mixture similar to that used in paper caps. A strip of lead is soldered to bottom of box so it can be easily attached to rail by bending strip around top of rail, and fires when engine runs over it. (Fig. 74 b).

PAPER CAPS.

for toy pistols.

These are made similar to those described under Japanese Torpedoes with such variations of detail as are necessary to their special requirements. They are of course punched out by machinery, a sheet at a time.

WHISTLING FIREWORKS

The peculiar property of potassium picrate to whistle while burning has been known for a long time and has been made use of for producing the amusing whistling fireworks. To make this article:

Disolve 1 lb. picric acid in the least possible quantity of boiling water, in a porcelain receptical; add ¼ lb. potassium carbonate, little by little, stirring continuously. Then add 1 lb. powdered saltpeter. Stir thoroughly; allow to stand for one hour and remove to a heavy piece of filter paper placed in a glass funnel where it can drain. When dry crush to fine powder with a wooden roller. Very small quantities should be handled at a time as an explosion will cause disastrous results. The dry powder may be rammed into tubes from ¼" to ¾" diameter and will produce the whistling sound when burned. Bamboo tubes are most effective.

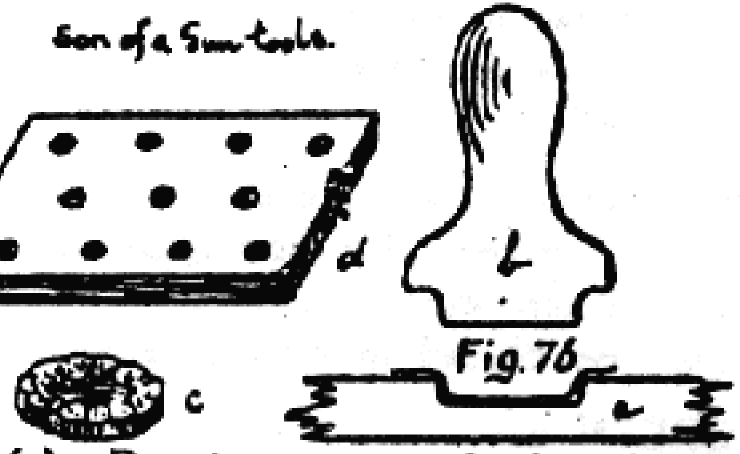
Owing to the ease with which potass; picrate detonates whistles cannot be used in shells but small tubes ¼" diameter and 2½" long when charged with the above composition may be place in the heads of rockets or fastened to the outside and arranged to burn as the rocket is ascending. Attached to wheels they are quite amusing, but the most effective use for them is when a series of six or eight ranging in size from ¼" to ⅜" diameter are set side by side like a Pandaen Pipe and burned simultaneously.

SON OF A GUN.

(Spit Devil—Devil on the Walk).

This amusing little piece of fireworks consist of a disc about one inch or more in diameter which, when scratched on the pavement gives off a continuous series of little explosions, burning from one half to three quarters of a minute. On account of somewhat resembling candy losenges a number of fatal accidents have occured by small children swallowing them. For this reason their sale has been forbidden in some sections. They are made as follows: (Fig. 76)

Secure a number of boards of ⅜" material, and bore holes into them ¼" deep and 1¼ diameter somewhat as shown at (a). Turn up a puncher like (b) which will work easily in the holes. Cut some red Foudrinier tissue paper into circular pieces 2½" diameter. Lay them over the holes in board and punch in. Pour into these the composition given below and fold over the edges of the paper as in (c). Permit to set and when hardened they may be removed and thoroughly dried when they will be ready for use.



SON OF A GUN COMPOSITION.

Mix five kilograms of powdered gum Arabic with five litres of water, adding water gradually with constant stirring. Then add 1½ kg. Magnesium carbonate. Place this in a water bath with a thermometer arranged so that temperature can be carefully observed and heat to 50°C. after whish add a mixture of one kg. white phosphorus and stir until entirely melted. Continue stirring while cooling to 25°C. after which add a mixture of 2½ kg. red ochre and 3 kg. potass; chlorate and stir until a perfectly smooth product results after which it may be poured into the paper molds as above. Great care must be used to prevent accidents in all mixtures containing phosphorus and chlorate of potass.

PHARAOHS SERPENTS EGGS.

This remarkable substance consists of small pellets of sulphocyanide of mercury which has the remarkable property of swelling 25 to 50 times its original size when lighted, producing a long snake like ash. To prepare, make a concentrated solution of mercuric chloride and add little by little a solution of potassium sulphocyanide, stirring constantly. A greyish precipitate will be formed and when the last drop of sulphocyanide added no longer produces cloudiness permit the mixture to settle. Drain off as much as possible of the clear supernant liquid, remove precipitate to a paper filter placed in a glass funnel and wash slightly. When thoroughly dry reduce to a fine powder. When ready to form the eggs moisten very sparingly with a week solution of gum arabic to which may be added a pinch of saltpeter and form into cones with the appliance shown in Fig. 77.

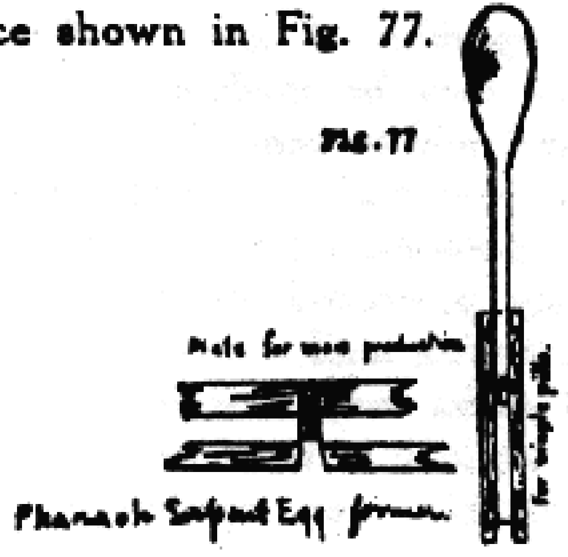


Fig. 77

MAGIC SERPENT, (Black).

This German device produces an immense long black snake, otherwise quite similar to the Pharaohs Serpents but in no ways related chemically.

Naptha pitch	10
Linseed oil	2
Fuming nitric acid	7
Picric acid	3½

Reduce pitch to fine powder; add linseed oil and rub in well; add strongest fuming nicric acid, little at a time. Allow to cool for one hour. Wash several times with water, the last time allowing mass to stand in the water for several hours. Thoroughly dry; powder fine and add picric acid, rubbing it in well. Moisten with gum arabic water and form into pellets about the size of a #4 star.

The naptha pitch can only be obtained in Germany and then with considerable difficulty. A fairly good article may be made by melting together equal parts of Syrian asphaltum and roofing pitch. To the final product add 5% stearine when forming into stars.

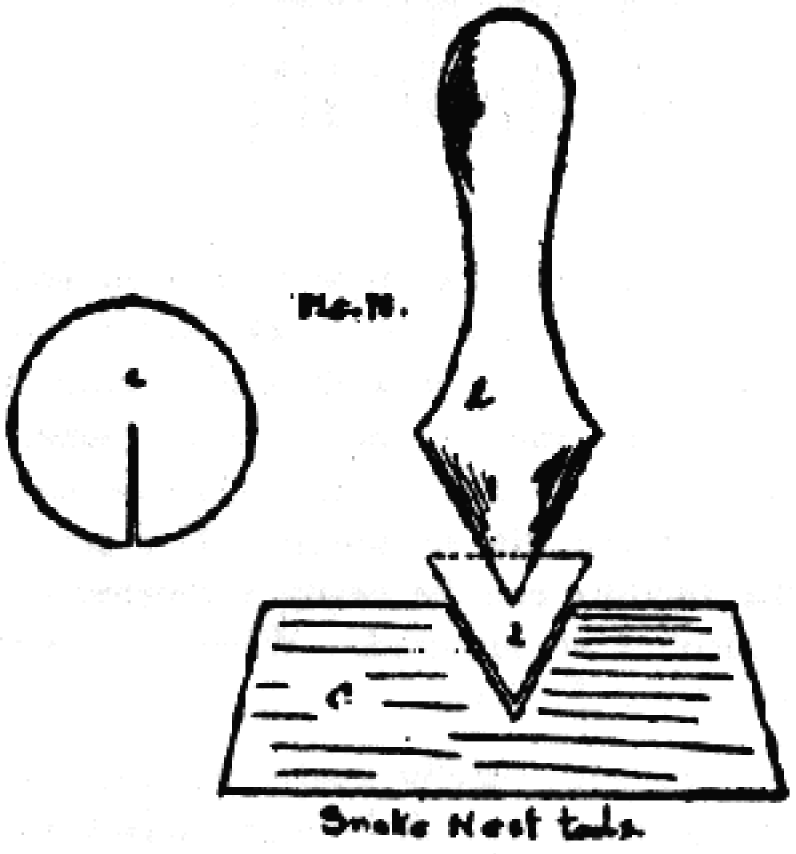
SNAKE NESTS.

(Snake in the grass).

These consist of small cones of tinfoil containing a preparation which, when ignited, produces a grass green pile of ash from which presently emerges a "Pharaohs serpent".

Cut some tinfoil into circles 1½" diameter. Cut these again from the periphery to the center as shown in Fig. 78. (a). Fold them around the former (b) so as to make little cones and insert into block (c) filling them with the following composition:

Fig. 78.



Saltpeter	1
Ammonium bichromate	2
Dextrine	1

When quite full up to the edge of the block, press into center a pellet of Pharaoh's Serpent powder. Fold over the edges to the center and remove from block. To use, light at top of cone.

COLORED FLAMES.

These are made by disolving various substances in alcohol, A copper can filled with cotton is impregnated with the alcoholic solution. It is lighted by a tuft of cotton left protruding from the opening. (Fig. 79).

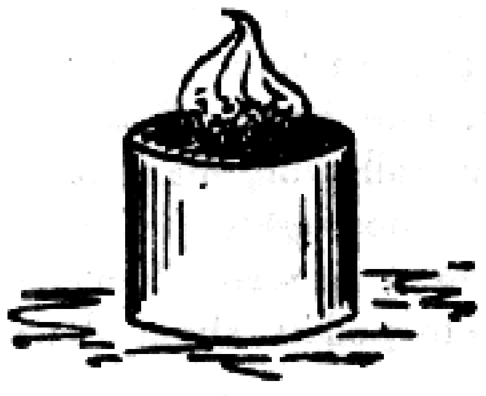


Fig. 79

For Green Flame	use Boric acid
Red "	Strontium or Lithum chloride
Yellow "	Sodium chloride
Blue "	Copper sulfate or Caesium carbonate

Before lighting sprinkle a little of the powdered chemical over the cotton where it projects from the can.

COLORED FIRE STICKS.

These consist of thin wooden sticks similar to applicators used by physicians for applying Iodine etc. to affected parts. They are dipped for half their length into colored fire compositions in a more or less liquid state.

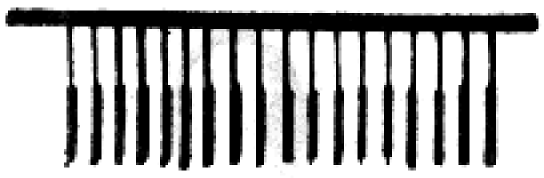


Fig. 80

One method is to melt one part of gum shellac in an, iron pot. Stir in five parts of very finely powdered strontium nitrate. To keep this sufficiently liquid it must be kept quite hot by the use of a steam kettle. This is for red sticks. Another method is to disolve the shellac in alcohol and adding the strontium. The proper consistency of the mixture can be easily regulated by using more or less alcohol as required. When the sticks are dried they are ready for use.

Green is not so successfully made, barium nitrate being substituted for strontium. A little lampblack improves the burning but detracts from the color, especially the green. The sticks are pushed into a grove in the bar as shown, Fig. 80 for drying.

Ruby and Emerald Shower Sticks.

These are much more effective and are made in the same manner as above, using following composition:

Strontium nitrate	6
Coarse aluminum	6
Potass perchlorate	2
Shellac	1

Disolve shellac in alcohol and add other ingredients, previously well mixed. Stir thoroughly to consistency of thick glue and dip sticks previously arranged in holder so they may be placed in drying rack.

For GREEN use:

Aluminum powder coarse	6
Barium chlorate	4
Shellac	¾
Alcohol	q. s.

The Japanese make a similar article of twisted paper but this requires a great deal of practice to learn, almost unattainable by western races.

SPARKLERS.

These are made in a general way like the above but in effect they throw off a shower of beautiful sparks. There are several varieties of sparkling sticks which are sold under this name. The principal one consists of pieces of wire or thin twisted metal, part of which is covered with a composition containing steel filings.

STEEL SPARKLER.

Fine steel filings	12
Fine aluminum powder	1
Potassium perchlorate	6
Dextrine or gum arabic	2
Water	q. s.

The steel must be protected from corosion with parafine. The gum should be made of the consistence of mucilage. Mix the ingredients thoroughly and add gum solution until a mixture is obtained that will adhere to the wires when they are dipped into it. This varies in different sections and with different runs of ingredients. In practice, bunches of wires are dipped at once and slowly withdrawn in a current of warm, dry air which causes the mixture to adhere evenly.

A sparkler of great brilliance and which is very effective may be made as follows: Take 3 lbs. of dextrine and add to same, little at a time, 12 pints of water, stirring continually so as to avoid lumps. Mix intimately 10 lbs. potassium perchlorate with 7 lbs. pyro-aluminum or finely powdered aluminum and add this to the gum water, stirring until a perfectly smooth mixture is obtained. Wood sticks may now be dipped into it to the desired depth while it is contained in a deep vessel, and placed in a suitable rack for drying. It may be necessary to dip the sticks several times dependent on how much composition it is desired to have on them. In this case they should be dried with the composition end up, the first time so that not to much composition accumulates on the end beyond the stick.

WATER FIREWORKS.

These consist mainly of five or six varieties as follows: (Fig. 81).

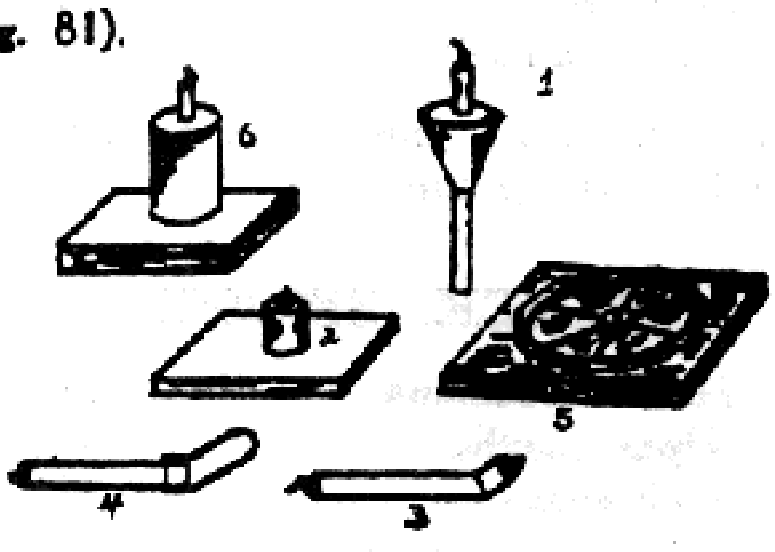


Fig. 81

No. 1 Floating gerb or roman candle. A cone shaped piece of light wood is bored with hole of suitable size to take the gerb or candle as shown. In order to secure an upright position with roman candles it is sometimes necessary to place a charge of iron filings in the bottom of case.

No. 2. Floating Tableau Lights are merely a colored pot of suitable size placed on a board.

No. 3. Diving Devils. A sharp gerb is fitted with a hollow head set at an angle with the case. Careful adjustment must be made so as to insure floating of the gerb which will cause it to dive into and come up out of the water properly. This is perhaps the most amusing piece of water fireworks as well as the one calling for the most careful work. The tip of float must be weighted so as to cause it to dive and yet be bouyant enough to make it rise again.

No. 4. Fish are made similar to the Diving Devil except that not so much adjustment is necessary as they only run around on top of the water.

No. 5. Water Wheels are an ordinary Vertical Wheel set on a board float as shown.

The Fish and Devils should be heavily coated with parafine when finished; even the nosing of the match should be protected in this manner and water proof fuse, properly primed, used for lighting.

Water fireworks are only practical on quiet ponds and small lakes and are usually fired from a skiff. Great care should be used to protect the supply in boat from sparks of those burning, in order to prevent accidents to the operator. #6 is a Floating Mine.

SMOKE and SPARK POTS.

These are used mostly in the large spectacular pyrotechnical pictures featuring volcanos etc. such as "The last days of Pompeii" "Burning of Rome" etc. They consist of short mine cases about 4" to 6" in diameter and 6" to 12" long. The compositions are

SPARK POT.

Meal powder	2
Fine charcoal	1
Sawdust	1

SMOKE SCREENS.

While these are really no part of the pyrotechnical art they do come under the heading of Military Pyrotechnics. They consist of a fine stream of Titanium tetrachloride which is sprayed from an airplane at a suitable height and which in falling produces the dense smoke intended to screen what is behind it. The liquid is projected backward from the plane at the same rate as the planes movement through the air so that the droplets fall perpendicularly.

SMOKE.

This branch of pyrotechny seems to have been somewhat overlooked though its possibilities for daylight entertainment to supplement night displays would appear to open an interesting field for those with the necessary imagination to develope it.

There are as many colors and tints of smoke as there are of flames and aerial combinations produce some really beautiful effects

The simplest form of smoke used in pyrotechny is the Smoke Pot used in the spectacles such as "Last Days of Pompei" where it is desired to give the impression of destruction by fire. A basic formular, subject to variation is:

Saltpeter	4
Lampblack	1
Charcoal	1
Realgar	1
Rosin	1

A starting fire as given below is also necessary.

A smoke pot developed by our War Department for making smoke screens consists of case 3½" diameter 6" high with a 1" opening in the top. The composition consists of:

Saltpeter	12
Pitch	8
Borax	2½
Chalk	1¼
Sand	1
Sulphur	1

The pitch is melted and while still hot the other ingredients, previously well mixed, are stirred in. Before the mixture cools and hardens it is pressed into case. As it is difficult to ignite, a starting fire of

Saltpeter	6
Sulphur	1¼
Antimony sulfid.	1
Meal powder	1

is used. About ¼" of this is placed on top of other composition before putting the top on case. This may consist of a wooden disc with hole, fastened in place with small nails or a tin can may be used as container.

SMOKE SHELLS.

(Smoke Clouds)

These are usually made by filling the shell case with a finely divided powder of the desired color cloud to be obtained. To the end of the shell fuse is attached a small bag of gunpowder which should be located as near the center of the shell as possible. This, when exploding serves to scatter the colored matter and produce the cloud. The arrangement of the fuse may be used as shown in Fig. 67.

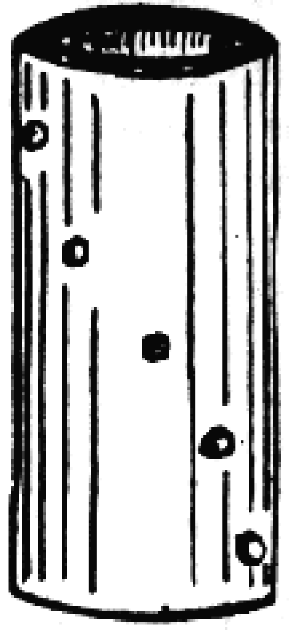
For RED	use American vermillion powder
BLUE	Ultramarine powder
GREEN	Paris green
YELLOW	Chrome yellow
WHITE	Chalk
BLACK	Ivory black

SMOKE POTS or SMOKE CASES.

The really beautiful effects, however, are produced by the burning of mixtures which produce a dense smoke of the desired color. For this purpose a paper tube 1 inch inside diameter and 4 inch long is desirable, into which are bored 4 or 5 holes ¼" diameter on a spiral line, at intervals as shown in Fig. 86. Both ends of the case may be closed with clay or wooden plugs. Do not pack smoke compositions. Ram very lightly.

WHITE SMOKE.

Potassium chlorate	3
Lactose	1
Sal ammoniac, finely powd.	3



As this smoke is not injurious to the lungs it may be used in doors for theatrical work. Rub the potass: chlorate and lactose together thoroughly, then add sal ammoniac, finely powdered, mixing only once more. Ram lightly. Another very good white smoke may be made as follows:

Sulphur flowers	16
Saltpeter	12
Fine charcoal	1

This is for outdoor use only. Use a little white star composition for starting fire.

BLACK SMOKE.

Hexichloroethane	24
Alpha naptha	6
Anthracene	2
Aluminum powder	4
Roman candle composition	6

Use white star composition for starting, if found necessary.

YELLOW SMOKE. (canary)

Potassium chlorate	1
Lactose	1
Paranitraniline yellow	2

Use red star composition for starting either of the above three.

YELLOW SMOKE. (olive)

Saltpeter	1
Red arsenic	1
Sulphur	1
Antimony sulphide	1
Meal powder	1

No starting fire necessary.

RED SMOKE. (bright)

Potassium chlorate	1
Lactose	1
Paranitraniline red	3

RED SMOKE. (dark)

Potassium chlorate	7
Lactose	5
Auramine	2
Chrysoidin	6

GREEN SMOKE.

Potassium chlorate	6
Lactose	5
Auramine	3
Indigo (synthetic)	5

BLUE SMOKE.

Potassium chlorate	7
Lactose	5
Indigo (synthetic)	8

Starting fire if needed.

Almost any pastel shade desired may be produced by combining the above formulas containing aniline dyes.

PART IV.
EXHIBITION FIREWORKS.
SNAKE and BUTTERFLY

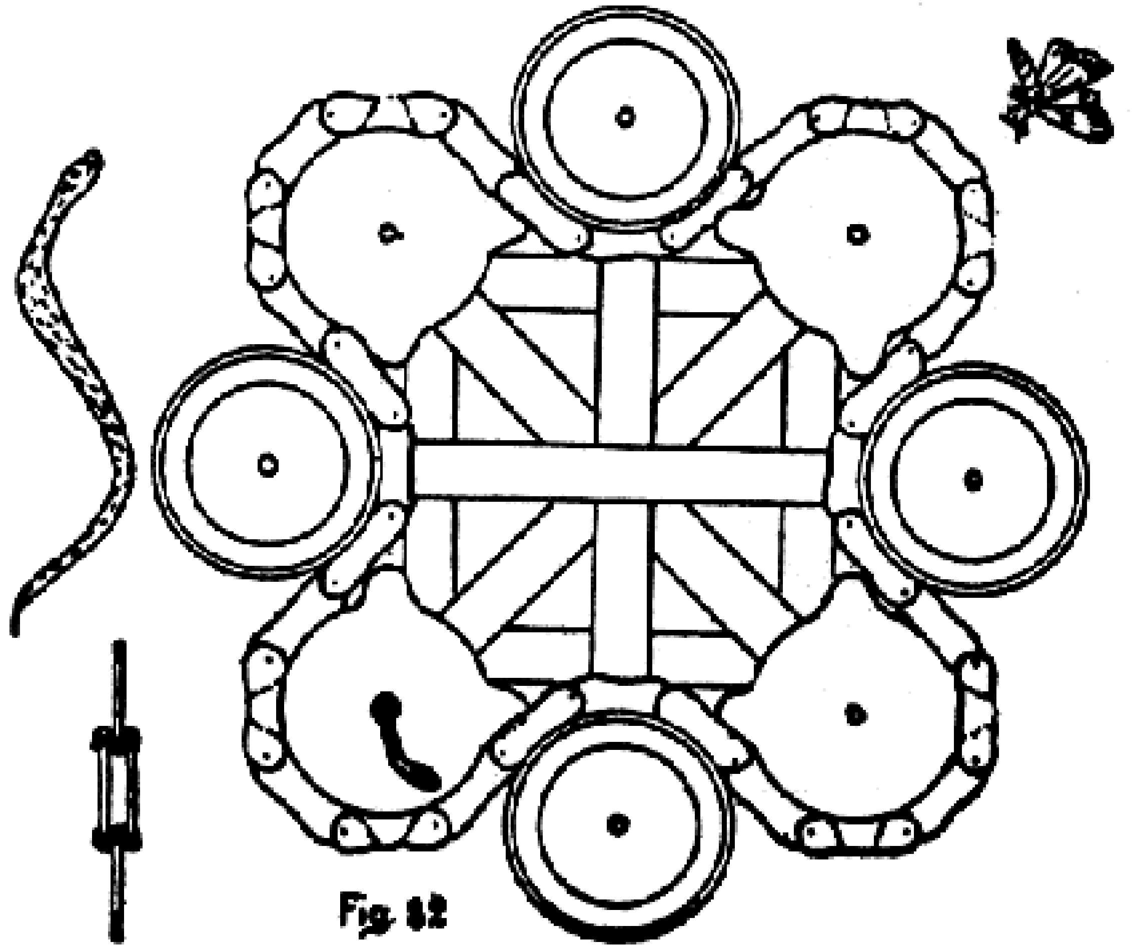
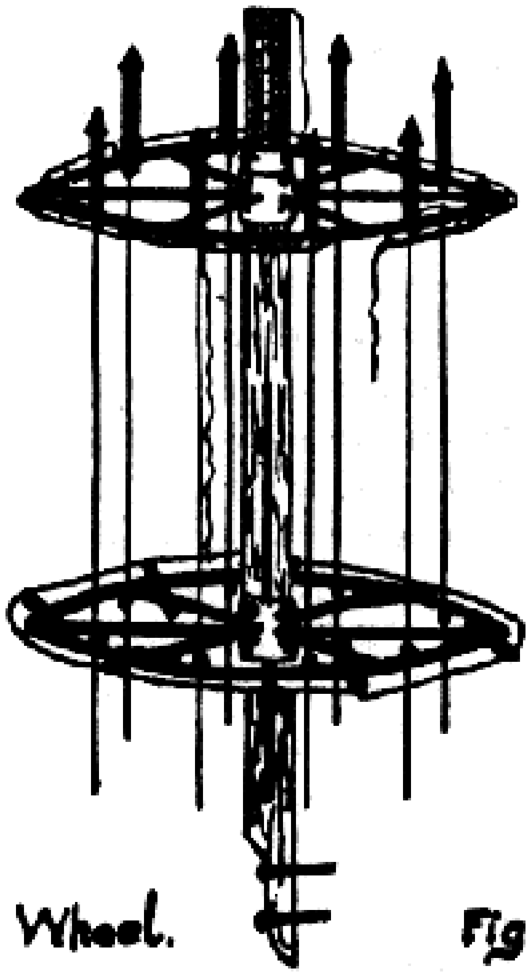


Fig. 82

This ingenious piece of fireworks is believed to have been devised by the Brock Fireworks Co. of Surrey, England, and created quite a sensation at the Cryſtal Palace when firſt shown about forty years ago. It conſiſts of a snake squirming around in the air after a butterfly which manages however to evade it.

The framework conſiſts of an endless chain of wooden links 4" x 8" bolted together and running on four sprockets and four idlers of a suitable size as shown in Fig. 82. When mounted, a crank is attached to one of the sprockets by which the whole is operated. The snake and butterfly are made of lancework which is attached to the chain.

ROCKET WHEEL



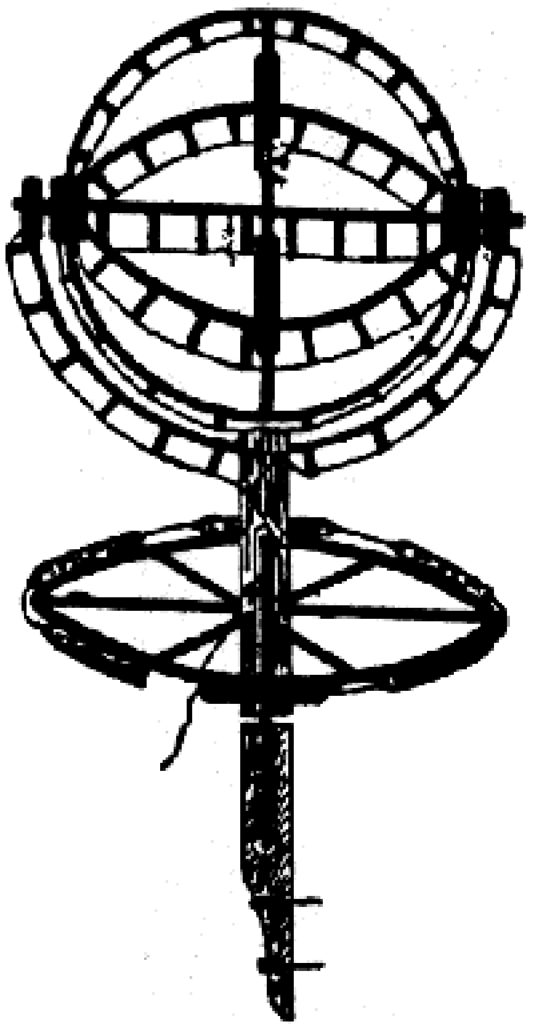
Rocket Wheel. Fig. 83.

This is a very old, yet always attractive device. It conſiſts of two wheels three feet in diameter, attached to opposite ends of an axle, arranged to revolve horizontally on a spindle as shown. The rockets pass through screw eyes along the rim of the wheel, and are matched to fire at intervals as the wheel revolves by being connected to successive drivers. On the top is a battery of roman candles. The top wheel is fitted with ordinary drivers containing ſteel filings and matched to burn two at a time, one each on opposite sides. The lower wheel is fitted with aluminum gerbs all to burn at once with the laſt two drivers of the top wheel. The latter are set at an angle with the axis of rotation so as to give a wider spread of fire. The battery of candles ſtarts with second pair of drivers of top wheel. (Fig. 83).

REVOLVING GLOBE.

This simple yet baffling and always intereſting device is conſtructed as shown in Fig. 84. The frame may be secured in different sizes, all ready for lances etc. from manufacturers of fireworks wheels in North Weare, N. H. or it may be conſtructed by the pyrotechniſt himself according to suggeſtions given in sketch.

When the piece is burning, the globe appears to be revolving firſt in one, then in the other direction in a moſt amusing manner.



Revolving Globe.

Fig. 84.

APPENDIX.

CHINESE FIRE CRACKERS.

As far as is known to the writer there has never been given in English a detailed description of this intereſting little article of pyrotechnics of which there are undoubtedly more made than of any other piece of fireworks. The ingenuity of the Chinese in its production in the unbelievable large quantities that they are made is only equaled by the many other unusual things done by this moſt patient and painſtaking race.

The yearly imports to this country of Chinese firecrackers amounts to three million dollars which divided among the various sizes, would amount conservatively to eight billion crackers.

The tubes or firecracker cases cases are 1¼" long, ¼" outside diameter and have a bore of 5/32". They are rolled of a grade of paper unknown in this country; perhaps the lowest grade of paper made, unsized and quite irregular in character, a sort of coarse blotting paper. A small amount of gum water or rice paste is used as a binder and the case is finished with one turn of very thin red, green or yellow paper. They are rolled in lengths of one to two feet and then cut to the required size.

Now a block is prepared for gathering about 1000 of these tubes into a hexagon shaped bundle, as follows. A piece of hard wood about 1" thick and cut into a hexagon, each side of which is 5" wide is provided with pointed wood or metal pins ¾" long and 5/32" diameter set into the wood base so that the above amount projects, and exactly ¼" apart. They are also arranged in a hexagon with sides 4" wide. A tube is now slipped over each pin until the entire block is filled, having previously provided a wood frame the same size as the outside of the block one half inch thick and having an inside diameter slightly greater than the assembled tubes so as to be able to slip snugly around them. This is slipped up and down a few times to shape the bundle nicely and a string tied around it to further secure same.

A piece of white paper is now pasted over the top of the bundle. When dry it is removed from the form and a piece of paper pasted on the other side when it is dried again. The under side is moistened at the edges and the surplus paper neatly rubbed off. When again dry the upper side is moistened all over and the paper over the top of each cracker is pierced with a punch or round pointed stick so that they may be charged with the necessary powder and clay. Some operators hold several sticks between their fingers at one time so as to be able to punch several holes simultaneously.

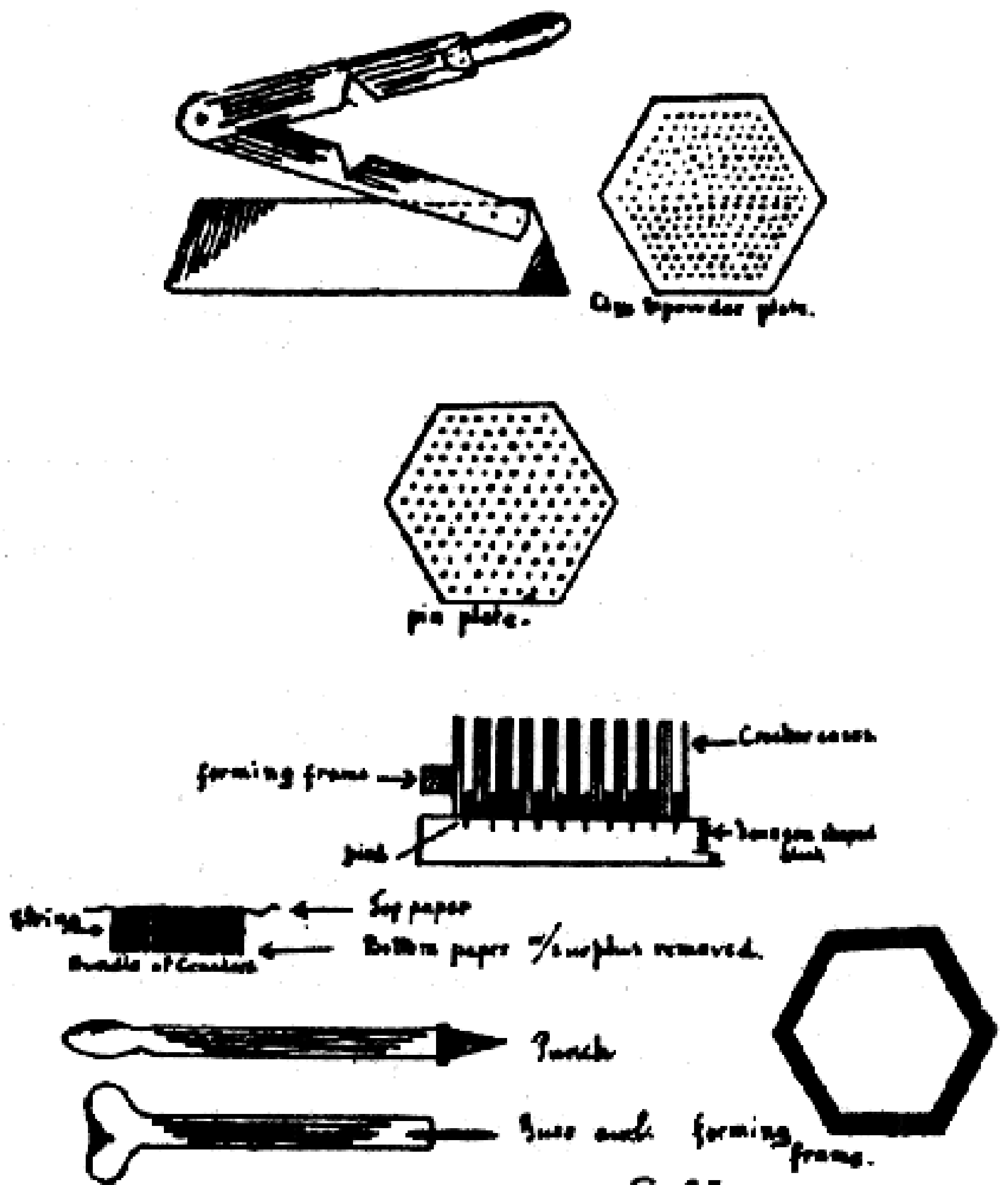


Fig.85.

A wooden board about one inch wider all around than the bundle of crackers and ¼" thick with ⅛" holes bored through it, corresponding exactly in position with the crackers in the bundle, is now laid on a smooth board, covered with finely powdered clay which is pressed into the holes in it, with the hand, until it is firm enough not to fall out when the piece is lifted. The surplus is brushed off and it is placed over the bundle of crackers so that the clay filled holes are exactly over the openings in the tubes. A slight blow is usually sufficient to to cause the clay to fall into the crackers. Any not falling out is pushed out with a stick. The bundle is jarred slightly against the table to make the clay settle. A similar operation is now performed with a thicker board containing slightly larger holes containing the powder charge after which the clay board is used once more as described above.

The top layer of paper is now moistened so that it it may be entirely removed and the clay which has become slightly moistened as well, is gently pushed down with a suitable rammer. It is then dried in the sun. The bottom end is now carefully dipped into water, turned bottom up and the paper removed from this side also, the clay pushed down and pierced with an awl for the purpose of inserting the match or fuse. This is however not done until the crackers have been again dried in the sun. After the fuses are inserted the ends of the crackers are pinched around it, about ½" from the end, by a crimper or two blunt knives hinged together at one end and having a V shaped notch cut out of the center of eath blade, so that when two notches approach from opposite sides they pinch the cracker together and cause the fuse to be held in place. When they are now finally dried for the last time they are platted together so as to form the packs of commerce. The platting and wrapping of the packs is such a dextrous performance that it is useless to try to describe it as it is only acquired by many years of succeeding generations doing the same thing.

The following formulas are in use for making the composition used in Chinese crackers and flash crackers:

CHINESE FIRE CRACKERS.

Saltpeter	50	45
Sulphur	25	18
Charcoal	25	25
Chlorate potassium		8
Sand		4

FLASH CRACKERS.

Saltpeter	50		
Sulphur	30	25	30
Aluminum powder fine	20	25	40
Chlorate potassium		50	30

A very important as well as extremely difficult part of the Chinese cracker is to make the fuse. Very tender and skilled fingers are required to produce this insignificant looking yet most requisite adjunct. A thin strip of the finest Chinese tissue paper, about ¾" wide and 14" long is laid on a smooth damp board; a little stream of powder is poured down its center from a hollow bamboo stick and with the tips of soft skinned fingers which seem to have an attraction for the paper and placed against the right hand lower corner, a rolling motion in the general direction of the upper left hand corner causes the paper to roll up into a twine like fuse. The slightest touch of paste secures the end and prevents unrolling. When dry it is cut into the required lengths and is ready for use.

NOTE. The information upon which the foregoing article was written has been supplied by Mr. Ip Lan Chuen, manager of the Kwong Man Loong Fireworks Co. of Hong Kong, China.

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★★AMERICAN★★

PYROTECHNIST

edited and published by Max P. VanderHorck
6359 Wunderlin Ave., San Diego, Cal. 92114

Volume 1 **January, 1968** **Number 1**

While going through my collection of material suitable for use in the expansion of Vol. 1 of THE POOR MAN'S JAMES BOND, I came upon my collection of the AMERICAN PYROTECHNIST. This was published by the late Max P. VanderHorck, who turned out 33 issues, retired, and some time after 1974 went to work on some super-nova way out there.

Max and I corresponded on several occasions after my accident, which he covered in "Explosives Like Granddad Used To Make....ARE ROUGH ON GRANDSON!" After that I subscribed and got his back issues.

Max was very concerned for safety in the handling of hazardous materials and had I, and the youth injured by his match-head rocket subscribed earlier, our accidents would have been prevented.

At first, I had little intention to reprint many of the submissions to Max's newsletter. Weingart's biography was all I was looking for. But as I went through the material I considered it a shame that Max's work should die. So many of the articles are so interesting that I'm sure Max would want you to have them. So here they are.

"EXPLOSIVES LIKE GRANDAD USED TO MAKE"

...ARE ROUGH ON GRANDSON!

"A little knowledge is a dangerous thing", to quote the poet. It is one thing to delve through encyclopedias, text books and formularies in search of rare and esoteric pyrotechnic information, just for the sake of broadening one's knowledge of the art. But it is often quite a different — and disastrous — matter if the researcher cannot resist the temptation to experiment with the formulations. The following is a case in point.

In the course of preparing a 48 page manual with the above interesting title, one of our subscribers was exposed to a variety of old pyrotechnic "recipes", some dating back to 1872 and calling for such ingredients as "ammoniacal sulphate of copper, baryta, carbonate of strontia, chlorate of potassa, fused nitrate of strontia, nitre and spirit of wine", among others. All went well until our friend tried to make primers for rifle shells, using a mixture for toy caps from an early edition of Weingart's PYROTECHNY. In this early printing, the Grand Old Man listed the ingredients, potassium chlorate, red phosphorus, powdered chalk and sulfur (and we can see many of our readers shuddering in horror at this point!) but did not stress the extreme importance of keeping them damp from beginning to end of the entire operation.

Our author-experimenter put this lethal combination in a plastic pill bottle and tried to mix the ingredients dry, intending to add water to make a paste afterward! The outcome was almost predictable; the mixture blew up, practically atomizing the bottle and blowing all the fingers off his left hand.

He tells us he "had always been under the impression that the lower explosives had no concussive force unless confined", a misconception which he rapidly discarded after September 1, the date of his accident. From here on, he says his interest in the pyrotechnic field will have to be "only intellectual", adding, "it would be nice if you would tell others that certain chemicals don't neccessarily have to be confined to go off with concussive force."

This reminds us of the lines from Kipling's "Jungle Book" — "Ye need not stop work to inform us; we knew it ten seasons before!" At the risk of being repetitious, this editor will again cite an equally injudicious experiment some years ago which left him with a partially deafened left ear, which still rings to this day. This he considers his "conscience" in writing about matters pyrotechnic and will not apologize to his readers for belaboring this point ever since 1965: don't experiment with chlorates unless you know exactly what to expect! Potassium chlorate is extremely unpredictable and hazardous when mixed with many common fireworks ingredients, sulfur for example, and in combination with red phosphorus it forms one of the most treacherous of "low explosives". Leave it alone unless you are an expert — and don't forget that even the "experts" sometimes get fooled!

With these dire words of warning out of the way, we can tell you something about the book, EXPLOSIVES LIKE GRANDAD USED TO MAKE, of which the author has about 50 copies left to sell at $2.00 each. We can even recommend it as a worthwhile addition to your pyrotechnic library from the viewpoint of historical interest, though definitely not as a basis for experimentation, since it includes many hazardous formulas which have been outdated in modern practice. As Dr. Ellern would say, it is "written with scissors and paste", meaning that the entire manual consists of reproductions of earlier works. As such, however, it would be well worth the investment for anyone not having copies of the three publications (all out of print) which it includes. These are: pages 1 - 7, the section on Pyrotechny from Dick's Encyclopedia of Practical Receipts and Processes, 1872; pages 8 - 35, The Modern Explosives Industry, by William Barbour, from Industrial Chemistry, Organic, Geoffrey Martin, Sixth Edition, London, 1922; and pages 36-48 from Techno-Chemical Receipt Book, 1896.

Scattered through these pages are a number of interesting fireworks formulas and processes which have not been included in the "classic" books but are still being used in the Orient. For example, "Japanese Matches", a unique sparkler-type novelty made in a twisted paper tube, mentioned by Weingart and Davis but without giving the formula. The essential ingredient is lampblack. Another similar formula includes lycopodium powder!

These reproductions, made directly from the originals, are of excellent quality, including the numerous illustrations, and printed on high-grade paper, bound in a good stiff cover. If you do not have the originals of the publications included, you can hardly go wrong by getting a copy of this manual, and you will have the added good feeling of helping the compiler pay his medical bills. We only regret that he did not diligently read his own publication, which states specifically on page 5: "Caution in the Use of Chlorate of Potassa (potassium chlorate — Ed.). This substance should never be kept in admixture with any inflammable matter, especially sulphur or phosphorus, as they explode with terrific violence by the most trivial causes, and not unfrequently spontaneously. All pounding and rubbing must be avoided."

** ** ** ** ** **

MATCH-HEADS STRIKE AGAIN!

Chula Vista, Cal., May 22.
(AMERICAN PYROTECHNIST EXCLUSIVE)

William Michael Vaughan, 17, a highschool Senior, has decided to give up amateur rocket experiments — at least with the kind of "rockets" made by stuffing match-heads into a metal case. His decision, unfortunately, comes a little late, after losing two fingers as the result of a recent experiment.

Mike was lucky. Except for a quirk of fate, he could have been more seriously injured, perhaps blinded. At least, he might have had to train himself all over again to write.

Here's what happened, as told to AP by Mike from the hospital ward where he spent ten days:

"Another boy and I were trying to duplicate the results some of our friends had achieved and make a rocket that would travel about 300 yards. I guess they were just luckier than we were, as they hadn't had any accidents!

"We hammered shut one end of a piece of copper tubing about 3/4 inch in diameter and 8 inches long. Then we packed it pretty full with the heads from about 40 books of matches and tried to make a nozzle at the open end by hammering it closed around a nail, which we would later pull out. That's when it blew up!"

Officer William Keller of the San Diego Police Dept. told AP he was visiting friends nearby and rushed over to investigate when he heard the blast. He found the boy with his left hand injured, metal fragments in his leg, and ½ by 3/4 inch piece of copper imbedded in the leather of his shoe. He called for an ambulance, and doctors at the hospital were forced to amputate the badly-injured ring- and little-finger of the left hand. The other youth was not injured, and no charges were brought against the boys, since it was felt they had learned their lesson.

Mike's parents readily gave their permission for us to print the story, hoping it might be an object-lesson to keep others from trying similar ill-advised experiments. Mike says he hopes so, too!

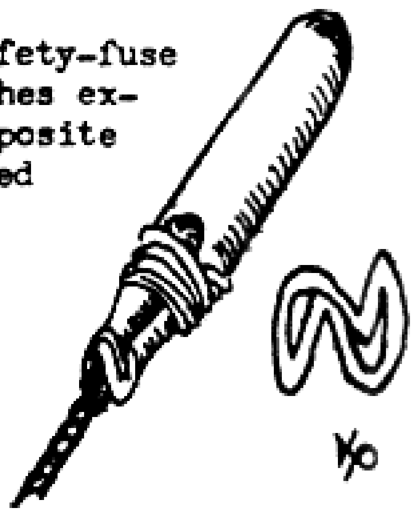
Dear Mr. Vander Horck: Regarding the story in June AP, "Match-heads Strike Again", most if not all beginners in the pyrotechnic field start experimenting at a very early age, usually under 21. For this reason, they begin with whatever they can get their hands on that will burn, INCLUDING PAPER MATCHES. (I know, because that is the way I got started.) Their parents think they are keeping them from harm by not signing for the chemicals they want and end up finding that they had more deadly, but more readily-available materials in their own grocery store all the time.

Some of us approach the use of match-heads with more care than did Mike. I am a physics major in my last year of college and have run some tests on these lethal (?) little chunks on the end of paper sticks; I believe I have found what may be an answer to the hazardous match-head rocket. Perhaps if we share it, we may save some precious fingers and eyes — that was my purpose in developing the following method:

Match-heads burn very quickly in comparison with more common rocket fuels, releasing almost all their energy in a very short burst or impulse. For this reason, a rocket made with them behaves like a tin can under which a firecracker is lit; it flies a very short distance, then glides upward a long way from its initial kick. Rather than trying to slow the burning of the match-heads, it was decided to make use of this kick. For this, a specially-designed nozzle was needed that would allow the gas to escape at the rate it was produced, but still confine it long enough to build up the needed thrust. After a number of tests, such a nozzle was developed, which can be easily and safely used by anyone. Here's how to do it.

Make a case from a piece of 3" gummed mailing tape, 8" long, rolled around a ½" dowel, moistening only the last turn. Close one end by crimping or taping it shut. NOTE: it must be securely closed. (This can be checked by applying pressure with the breath on the open end — Ed.) Now merely POUR in the heads from TWO PACKS OF MATCHES — NO MORE AND NO LESS — and do not pack them! Then cut off the excess of the tube, leaving about one full inch beyond the match-heads.

HERE'S THE NOZZLE TRICK: Insert a piece of safety-fuse all the way into the match-heads, with 2 or 3 inches extending, and crimp the open end around it from opposite sides of the case. This gives sort of a "Z" shaped opening, with the two creases sliding over each other, and actually forms two nozzles, one of which holds the fuse. An end view of this opening without the fuse in place is shown enlarged at the right of the drawing of the complete rocket, to make this clear.



The tapering formed by this constriction should extend the full inch from the charge to the open end. Now wrap a rubber band around the constriction as many times and as tightly as possible, being sure it is at least ½" back from where the fuse exits from the rocket. This pulls the openings closed and holds the fuse securely.

Attached to a suitable stick and launched, preferably from a tube, this rocket will go up with a "whoosh", sometimes reaching more than 200 feet! The tension of the rubber band gives a valve-effect, permitting the nozzle to open and shut according to the internal pressure. If placed as directed, it will not burn away until it has performed its task, which is to eliminate the need for packing the propellant!

— Peter Borger, Elmhurst, Ill.

Ed's note: Mr. Borger's instructions are passed along without reccomendation, pro or con. We had just about decided to drop further discussion of match-head devices after our June issue, since the devoted pyrotechnist finds them objectionable and unneccessary, even if readily available. We changed our mind and printed his letter (even did the illustrations from the samples he sent with it) because we were convinced of his sincerity in the cause of preventing accidents such as happened to Mike Vaughan. We agree with Peter — if you must play with matches, do it right!! And that, we sincerely hope, is the end of the match-head bit.

WHISTLING CHASERS - HOW THEY WORK

The pyrotechnic whistle (whistling chaser) is a device which, when ignited, emits a piercing whistle which continuously drops in pitch until the device burns out.

Most pyrotechnics buffs will recognize it as the device which pranksters tie to the ignition of a friends? car, going off when the car is started, and scaring the holy terror out of the owner unless he has encountered one before. Pranksters sometimes use another version of this device on packs of dogs. When ignited, the device zig-zags across the ground like a skyrocket gone wild, simultaneously emitting a piercing whistle. Mayhem usually ensues, with the terrorized dogs fleeing under a house or back porch to bark nervously from underneath in fear of their lives.

HOW THEY WORK

The pyrotechnic whistle is composed of three basic parts: a cardboard tube, a whistle powder charge, and an acoustical resonant cavity (an empty cylinderical space) in front of the whistling charge in the direction of the fuse. Typical cavity dimensions are 5/16 inches in diameter and one inch deep.

The empty space in the front of the tube forms a cavity which is resonant at the whistle frequency. The whistle mixture is a composition which has a burning rate that is much more sensitive to exhaust gas pressure than ordinary pyrotechnic mixtures.

When the whistle mixture is ignited in the tube, gas pressure builds up within the tube, at an instantaneous value which is much greater than atmospheric pressure. This pressure or shock wave travels to the end of the tube. The gas escapes but part of the shock wave reflects back down the tube until it strikes the surface of the burning whistle mixture. This additional pressure causes accelerated burning, and the pressure or shock wave is enlarged and reinforced by the resulting gasses as it is reflected off of the burning surface. The process repeats itself thousands of times per second, as determined by the dimensions of the cavity. As the mixture burns, the length of of the cavity increases, the shock waves take a little longer to travel its full length, and the pitch of the whistle drops as the whistle mixture is consumed.

NEW TECHNIQUE FOR PARACHUTE SHELLS

by Peter J. Borger

(Eds. note: Readers who have attempted to construct a "fail-safe" parachute shell by traditional methods — Weingart et al., know that it is quite a trick. Shrouds or chute may burn, or the chute fail to open, plummeting a flare to earth with consequent fire danger. Here is Mr. Borger's solution to this problem.)

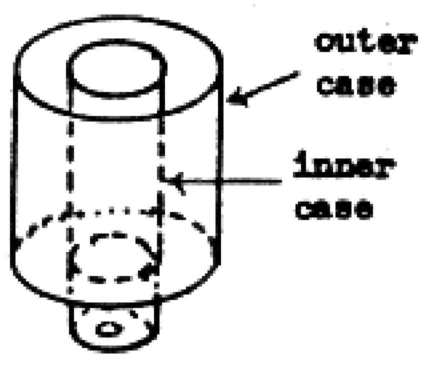


Fig. 1

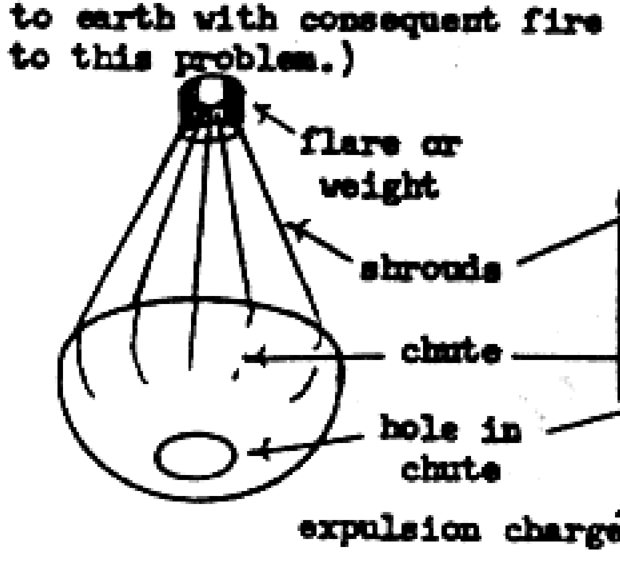


Fig. 2

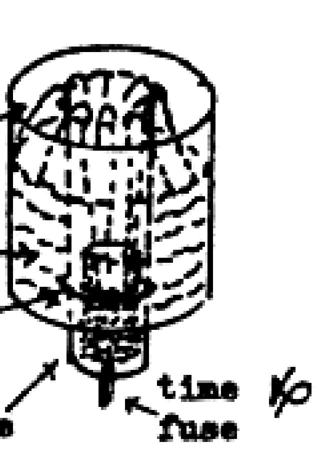


Fig. 3

This method of packing a parachute in a specially-prepared shell actually uses the force of the expulsion charge to open the chute as it is ejected. Fig. 1 shows the special shell, actually a central tube surrounded by a concentric outer case. Only the time-fuse, expulsion charge and flare go into the central tube, while the chute is packed into the jacket between inner and outer case.

A hole just large enough to slide over the central tube is cut in the center of the chute, as in Fig. 2, and it is pushed down in this inverted position to the bottom and carefully packed between inner and outer cases, surrounding the central tube.

The flare, properly primed to ignite from the expulsion charge, is then pressed down into the tube on top of it, with the shrouds leading up and over the top edges of the tube as shown in Fig. 3. A light closure or disc is, of course, pasted over the top to hold everything in place.

It can be seen that the expulsion charge will act only on the flare (or weight), not directly on the fragile parachute, which by means of the shrouds will be pulled from its jacket in an already-open condition. No exact dimensions have been given here, as it is intended only to illustrate the principle.

Though I failed time after time with the "standard" methods of packing such shells, I got twelve successes out of a dozen shells with this one, and not a one caught fire as it left the shell! The hole in the parachute, by the way, is small enough in relation to the overall area that it does not drastically affect the descent rate.

* * *

A CHEAP AND SIMPLE POWDER SCALE

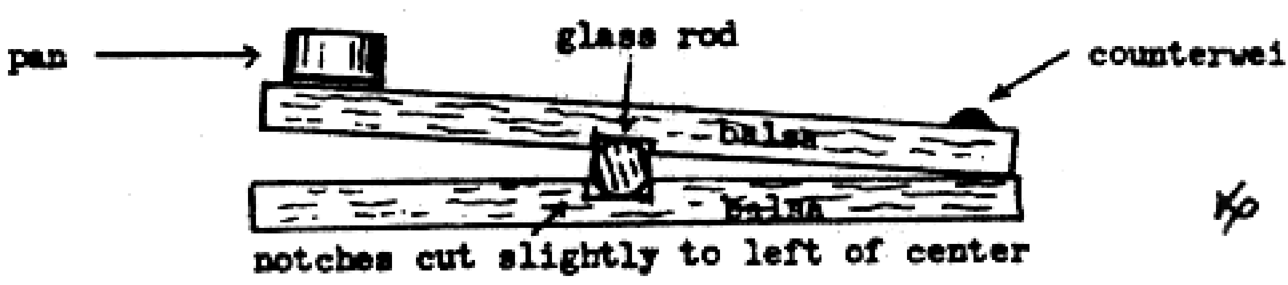
by PETER BORGER

(Readers of the now defunct PYRONEWS which we edited in 1966 and 1967 will recall the articles appearing in the Jan. and Feb. 1967 issues describing simple methods of making black powder in small amounts for experimental purposes. Many of our present subscribers, however, may not have seen those articles, and many new kinks and techniques have since been submitted by readers. Thus we believe it is time to print a series of updated articles on the subject, including simple and inexpensive methods for weighing, mixing, pressing and granulating small samples of black powder. Here is the first of these articles. — Ed.)

The first problem in making black powder arises in the cost of the weighing apparatus. I myself could not afford $12 or so to buy a gram scale, and a postal ounce scale makes too much powder in one batch. I have therefore designed a small scale that gives a fair measure of consistency. It measures one unit of weight at a time; thus a black powder formula such as 6 potassium nitrate, 1 charcoal, 1 sulfur can be measured in 8 operations to produce the proper proportions on a small scale. (The exact weights in grains, grams or ounces is unimportant, but the experimenter wishing to calibrate his scale may take advantage of the fact that a nickle weighs just 5 grams. —Ed.)

I made the scale of balsa wood, which is cheap and can be purchased at any hobby shop. The center pivot is a glass rod, kept in place by cutting grooves in the wood slightly closer to the "pan" end than to the other, as illustrated below. In operation, the pan, for which I use the plastic top of a medicine bottle, is initially in the "up" position. The powder is sifted slowly into this pan until it drops to the "down" position. This gives one measure of weight. The amount of powder required to tip the scale may be adjusted by attaching a small counterweight to the opposite end of the beam — I use a thumbtack.

The powder is, of course, dumped into the mixing receptacle after each such measurement, which is simple, since the top beam can be lifted right off the glass rod and inverted. In the case of the above formula, which is close to standard for black powder, the operation would be repeated 6 times for the saltpeter and once each for the charcoal and sulfur. Thus, any formula can be duplicated in the very small amounts which are the keynote to safe experimentation.



(For obvious reasons, we have taken the liberty of dubbing Mr. Borger's little device the "CLOTHESPIN BALANCE". Its beauty lies in its simplicity, and while many refinements could be added, it should work admirably in the use for which it is intended. — Ed.)

HOME-MADE BLACK POWDER

by PETER BORGER

(Editor's Note: This is the second in a series of articles by Mr. Borger. The first, which appeared in our last issue, described a simple balance for weighing ingredients. This and the following two will give details on grinding, mixing, pressing and granulating black powder in small quantities, using home-built equipment.

Old-timers in the business know that hand-made powder cannot equal commercial products such as those of DuPont, processed with massive machinery. But we feel that an understanding of the principles and techniques of its manufacture ought to be one of the first lessons for the newcomer to pyrotechnics. Like the ancient experimenters, Mr. Borger has met and solved many problems in his own way, which we think are worthy of passing along to old-timers and newcomers alike. Where we thought our own remarks might help to clarify, they are included in parentheses -- like this.)

***

GRINDING

Most of today's mortars and pestles are made of glass, but I found that powder mixed with a wooden pestle in a glass mortar burned faster and with more regularity. I made a pestle from 1" diameter dowel, 4" long, by rounding one end with sandpaper, which shortened the grinding time. (Mr. Borger's formula is 6 parts potassium nitrate, 1 charcoal and 1 sulfur by weight. The saltpeter should be ground first, as fine as possible, then the charcoal and sulfur added and all ground together. The starch or dextrin added as suggested below should be about ½ of one part. The editor uses a mixture of 15 potassium nitrate, 3 charcoal, 2 sulfur and ½ dextrin.)

While grinding, be sure you're not just grinding around the edges of the mortar. Push the pestle frequently across the center of the bottom. The longer you grind, the faster the mixture, but avoid generating excessive heat. It is best to grind for one minute, rest a minute, and then continue.

(After the dry ingredients are thoroughly mixed and ground, add a little water slowly and continue grinding. If the water is diluted with 50% alcohol, the remaining steps will go faster. If the dextrin or starch has not been included with the dry ingredients, it should be added at this time. The older formulas did not call for it, but experience has shown that makes the powder faster by improving incorporation and adhesiveness. Yellow dextrin is recommended, but even laundry starch does a good job. Remember, the water should be added very cautiously, a little at a time with continual mixing, as the dry powder does not absorb it readily. Too free a hand at this stage can ruin your efforts by making a "soup" instead of a paste, which is what you should be aiming for. Mr. Borger gives the following reasons for this precaution:)

Note that the amount of added water is very important to the final product because, (1) water dissolves the potassium nitrate very readily; (2) the charcoal and sulfur are insoluble in water but they will absorb the potassium nitrate/water solution, but; (3)like a sponge, they can only absorb a certain amount of this solution, and (4) the potassium nitrate dissolved in the excess water will therefore no longer be incorporated in the mixture but will recrystallize out to form a white crust on top of the powder, or around the edges, as the excess water evaporates. If you see any such white edges or crusts after the mixture dries thoroughly, you have used too much water and upset the ratio of saltpeter to the charcoal and sulfur.

Perhaps you have seen the TV commercial where two brands of catsup are poured side by side on a plate and allowed to sit for a few minutes; then the plate is tilted and water runs off one sample but not the other. This is a good test to apply to your powder after moistening, bearing in mind that any water running off is carrying part of the saltpeter with it, weakening the powder. A little experimentation will give you the feel of how much water to add. A batch of powder that has become too gooey need not be discarded, as long as none of the water is allowed to escape, but can be reworked after drying, adding less water than the first time.

(Pressing the damp powder into a cake, which should follow immediately after the grinding, mixing and dampening, is described in Mr. Borger's next article, which will appear in our December issue. We suggest postponing the operations here described until you have read that article. However, if you are inclined to experiment in the meantime, it should be pointed out that the black powder mixture at this point, after drying, is highly inflammable and will burn with extreme rapidity, producing great heat and volumes of smoke. Consequently, it should be treated with the greatest respect. While black powder is not very shock- or friction-sensitive, it ignites readily from the smallest spark, such as might be caused by the striking together of ferrous implements or tools. Suitable precautions to avoid such accidents will be given in later articles.

Mention should be made here of the availability of the ingredients. Potassium nitrate, KNO_3, is carried on the shelves of most well-stocked drug stores, usually in the granulated form looking about like table sugar. But since the best results are obtained by first reducing it to the consistency of powdered sugar, a rather laborious process, the double-refined powdered grade obtainable from chemical-supply houses and sources mentioned elsewhere in our pages, is much to be preferred for making black powder. And don't overlook the desirability of treating it with magnesium carbonate as described on page 5 of the September issue to prevent its caking in storage.

An excellent grade of sulfur is the very fine dusting type sold at nurseries, garden-supply houses, etc. as a pesticide. This nearly white flour is both cheap and excellent. It is to be preferred to the "flowers of sulfur" sold in drugstores at higher cost, although this yellower type will serve the purpose.

The best charcoal for use in black powder is the softwood type sold as "willow dust" by suppliers of pyrotechnic chemicals. As a substitute, hardwood charcoal can be used, such as by pulverizing charcoal briquettes or even the charcoal stomach tablets for relief of flatulence. For the best powder, however, the softwood variety is recommended.)

***

AN INEXPENSIVE POWDER PRESS and A NEAT, CHEAP GRAIN CUTTER

by PETER BORGER

(We have combined articles number 3 and 4 in this issue to make the entire series available in our 1968 issues. The first two described Mr. Borger's methods of measuring, mixing and grinding small amounts of black powder in the home lab — see Oct. and Nov. issues.)

THE PRESS: The powder press is a most important tool in the manufacture of black powder. This device determines the texture of the final product and thus its quality. A home press can be constructed from two scrap pieces of 2 x 4, two ½" dowel rods, some thin lucite or other plastic material, a hinge and a 2-foot piece of clothesline rope.

Two ½" holes are drilled deep into the 2 x 4 pieces and pieces of dowel inserted to extend a couple of inches beyond the end of each. A recess is then cut into the opposite end of each 2 x 4 to accomodate the two sides of a regular door hinge (costing about 68¢ a pair), the two pieces are lined up and the hinge screwed down flat, so that they will open and close like a book, as shown in FIG. 1.

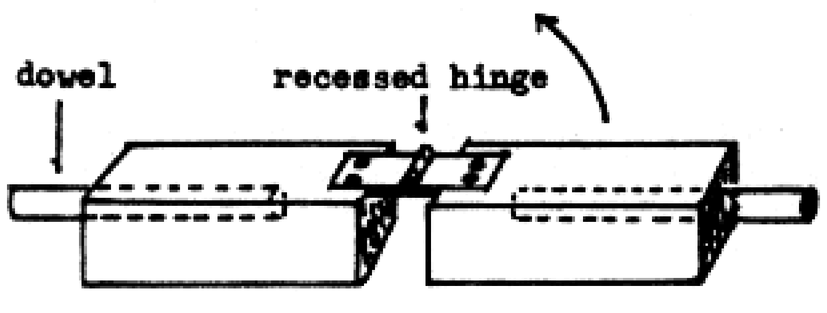
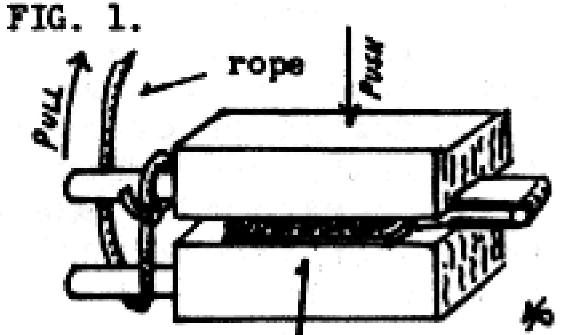


FIG. 1



powder cake between tin-foil & plastic strips

FIG. 2

Now two or three thicknesses of plastic material are glued to the top of each block to keep the powder cake and tinfoil from sticking in the following operations (but can be eliminated without serious consequences).

Cut some 2" square pieces of tinfoil and, laying one of them on either block, place a small pile of damp powder on it and another square of foil on top. Then fold the other block over to hold the "sandwich" together, pressing it firmly by means of a piece of rope tied to the upper dowel and looped under the bottom one, placing the press on the floor with one foot on top of it and pulling up on the rope, as shown in FIG. 2. The idea is to put just enough damp powder on the foil to spread to the edges after pressing as firmly as possible.

Keeping the rope taut, wrap it around the dowels a few times and tie it off; leave the press in this condition for an hour or two, then remove the rope and lift the top. Leaving the foil in place, remove the "sandwich" and let it dry for 12 hours, after which the foil is taken off and the cake allowed to dry at least 24 hours, depending on its thikness and the ambient humidity. It is then ready for cutting as described below. (The total cost to me for this press was 88¢, but if you have to buy a ½" bit, it can run up to $1.88!)

(Ed. Note: CAUTION -- Because of the intimacy and incorporation of ingredients in pressing, the black powder will now burn in a flash, even in cake form, if ignited by any flame or spark. Be extremely cautious in handling it during the following operations!)

THE CUTTER: This is made from about 20 injector razor blades, 3 blocks of ½" balsa cut to about 2" square, and 2 small hinges. Two of the blocks are prepared identically by cutting 10 parallel and evenly-spaced slits into the surface and gluing 10 blades into them, cutting-edge up. Since such blades are 1¼" long, the total space occupied by the 10 blades should also be 1½" to form a square cutting-surface, centered on the block. While the glue is still pliable, the blank piece of balsa is pressed down on the cutting edges of the blades to insure they are set in at uniform height.

After the glue dries, the cutting blocks are attached by means of the hinges to two adjacent sides of the blank block. This is done by inverting each cutter block on the blank and attaching the hinges, to insure proper alignment. The end result is shown in FIG. 3.

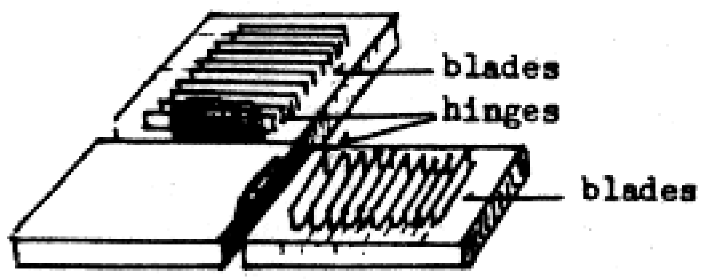


FIG. 3

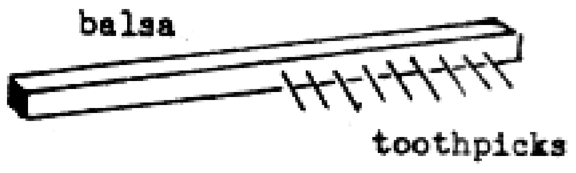


FIG. 4

OPERATION: A cake of the powder pressed in the previous operation is centered on the blank square of balsa and the first cut made by folding and pressing down one of the two hinged blocks with blades. This is then lifted and the other block pressed down, making a second cut at right-angles to the first. These operations cut the powder into about 100 squares, depending on the number of blades and spacing. Different cuts can be made by adding cutting-blocks with blades oriented diagonally to the two free sides of the cutting-block. Your imagination sets the limit!

I found that if a good clean cut is made, the powder may stick in between the blades, making a second cut impossible. To remedy this, I designed a "fork" of balsa and toothpicks as in FIG.4, which is inserted into the blade separations above the powder to hold it down as the blades are lifted. The finished cut powder should be shaken in the finest sieve available at the local grocery store . The dust that falls through can be used as meal powder, and what is held back used as grain powder, the "grain" depending on the spacing of the blades.

(I have to say that I can't take full credit for this idea; my girl-friend came up with the germ of it, which I have modified only slightly!)

* * *

BASIC SHELL CONSTRUCTION - PART I

By Bill Withrow

This is the first in a series of articles on the construction of Exhibition shells. In this series, information will be presented in detail on methods used by commercial manufacturers, as well as methods more suited to the requirements of the amateur pyrotechnist, starting with fundamentals and progressing to the construction of the most intricate and spectacular shells used in large displays. We invite both your comments and questions on this series.

MORTARS

Since they are the simplest components of an aerial display, yet perform the essential task of getting the shells into the air at the proper angle, we begin with a discussion of mortars, also known in the trade as "guns". A mortar is simply a short, smooth-bore cannon. The ones used in fireworks displays are usually made from steel pipe, one of the rare examples in fireworks where explosive materials are confined in metal containers. To prevent serious injury to the operator in the event a shell should explode while still in the "gun", MORTARS SHOULD ALWAYS BE BURIED to within a few inches of their open ends before using! It is also common practice, and highly advisable, to place a barricade of sand-bags or logs between the mouth of the mortar and the operator. In soft ground, a plank is often buried under the mortar to prevent its "digging itself in" as a result of recoil and becoming completely buried.

Mortars made of paper or galvanized iron are sometimes used in the smaller sizes. Paper mortars are recommended for amateur use, especially during first attempts at shell construction, since they are safer and cheaper than metal mortars. These also should be buried, since hard paper fragments are quite capable of inflicting serious injury.

Commercial manufacturers often make "boxes" of 3" diameter shells in paper mortars as finale salvos; these mortars are made of tubing on which newsprint is rolled and can usually be obtained free for the asking from newspaper printers. Other sources suggest themselves, such as markets which use large rolls of plastic wrapping material with the same type of core. The newsprint cores vary in length from 3 to 9 feet and can be cut to the desired length with a wood saw. A 2-foot length, sealed at one end with a 2" length of round wood that fits tightly inside the tube, glued and nailed in place, makes an excellent mortar. The plug may be cut from a 2" x 4" block, preferably yellow pine. The inside of the open end should be made slightly funnel-shaped with a wood rasp to aid in inserting the shell. Of course, the diameter of the mortar determines that of the shell to be used in it, taking into account "windage" or tolerance between the O.D. of the shell and the I.D. of the mortar (this should not be a "tight fit"; a typical shell made for a mortar of 3" I.D. would be of 2 3/4" diameter. These factors will be covered in future articles.).

Metal mortars may be made of ordinary steel pipe. Recommended construction is to plug these with a steel disc turned to fit the pipe and welded flush in one end. Most machine shops have the material and equipment to do this work. Alternatively, the pipe can be plugged with wood as for paper mortars, with machine bolts inserted through holes drilled through the pipe and wood for this purpose. It is recommended that two such bolts be used, inserted at right-angles to each other.

Most professional fireworks companies have mortars made of reclaimed pipe from salvage yards, since the stress on a mortar is not too great during normal operation, except in the case of detonation of a shell in the mortar, which no reasonable steel tubing will survive anyway. Thus, new pipe is not required — only that which is reasonably sound. Surface rust and pitting are of no consequence. If trouble is encountered in obtaining pipe, specify ASTM schedule 40, "steel pipe for ordinary purposes".

Galvanized iron mortars are not recommended, though they are used where large numbers are needed at low cost and where more shells must be fired from each mortar than could reliably be done with paper mortars, or where supplied for small displays by a company, to keep losses at a minimum in case they are not returned. Ordinarily, the slightly lower price does not offset the inferior quality.

(Ed. note: Opinions differ on this point; we know one operator who customarily uses racks of 8 to 12 such mortars in a horizontal row, held in place by a wooden framework staked in place entirely aboveground, for finale salvos. He feels that the thin, flexible metal of such tubes would split along the riveted seam in case of detonation of a shell, rather than shattering into fragments like heavier metal.)

When firing shells, never under any circumstances allow any part of the body to extend over the mortar. Shells should be rested on top and inserted by tipping them upward with the leader so they fall into the tube, which can be done without placing the hand directly over the mortar. After the shell is inserted, the length of leader extending outside should be observed to be sure the shell has gone all the way to the bottom. If it has not, try "bouncing" it by pulling and releasing the leader gently. Again, be sure no part of the body is over the mortar at any time. Assume that the shell might go off at any instant — it just may! Sparks remaining in the mortar from a previous firing can sometimes ignite the lifting-charge, causing the shell to go unexpectedly.

Standard shell sizes are 3", 4", 5" 6" and (rarely) 8" nominal diameter. (Note, however, that for unexplained reasons many domestic suppliers advertise them by circumference rather than diameter, in which case the above sizes would be called 9", 12", 15", 18" and 24" respectively! - Ed.) Japanese shells come in the above sizes, as well as 12" and larger diameters, and have in the past been made even up to the size to fit a 36" mortar. Because of the labor and cost, such monsters are no longer made, since the same effect can be achieved by firing several smaller ones.

Regarding mortar length, the rule of thumb is that it should be at least 5 times the internal diameter. 3" mortars are usually 18" long, while 4" through 8" ones are generally 36" in length. The best sizes for amateurs are 3" and 5". Again, always remember the cautions listed above. Any explosive surrounded by metal is a potential bomb, no matter what it is supposed to be. Even in "normal" operation, a shell leaving a mortar can tear off a hand — and has done so!

BASIC SHELL CONSTRUCTION - PART II

By Bill Withrow

In addition to the mortar from which they are fired, most exhibition shells have at least five other things in common: a quickmatch "leader" with which the shell is fired, a lifting charge which propels the shell from the mortar, a shell case of some kind, a time fuse which ignites the bursting charge in the shell at the proper instant, and the contents of the shell which produce the desired effect. In this article, we will consider the time fuse.

Since the primary duty of the pyrotechnician is to insure the safety of both his audience and himself, it is essential that the shell time fuse be reliable. The time fuse must cause the shell to burst high in the air; a shell which bursts too soon is a hazard to the operator, one which bursts too late may be a hazard to the audience. (The former case is known as a "flower-pot", the latter case is known as a "low burst." A shell which fails to burst at all is known as a "dud.")

There are two basic types of time fuses used in exhibition shells: rammed fuses (also known as "roman" or "filled" fuses), and commercial fuses. The rammed fuse is generally used when relatively short time delays are required, as between the breaks of multiple-burst shells. The rammed fuse is simply a strong case rammed with a suitable composition, as described in both Davis, and Weingart. Details of construction of rammed fuses will be presented in subsequent articles.

Commercial fuse, like blasting (safety) fuse, consists of a core of black powder contained in a wrapping of yarn. Over the yarn are alternate layers of asphalt and cloth tape. The fuse is given a finish coat of a white clay, in the case of fireworks fuse, or wax, in the case of blasting fuse. Commercial fuse is available in 1/4" and 3/8" diameters, and in three different coreloads (The amount of powder contained in the fuse, per foot.). While the 1/4" fuse can be used in small shells, the 3/8" fuse is more reliable and easier to use. In any case, the "heavy core" fuse should be used.

Both the fireworks fuse and the blasting fuse are almost impossible to ignite by flame unless the fuse is slit to expose the powder core. In addition, the flame from both is confined almost entirely to the "spit" of flame from the end of the fuse. Consequently, a means of positive ignition and flame transfer to and from the fuse is required. It is also desirable to seal the ends of the powder core to prevent the powder from falling out as a result of normal shock encountered in operation.

Although priming the ends of the fuse with a paste of meal powder and water will work, the burning rate of the fuse (normally 2½ seconds per inch) may be altered as a result of the moisture from the priming. A more reliable method is to "cross-match" the fuse. In this method, the fuse is cut about twice as long as the amount needed for the proper delay. Small holes are then drilled thru the fuse - the distance between the holes being the distance required for the proper delay - and a piece of raw quickmatch is threaded thru each hole. For maximum reliability, this quickmatch should be the best quality available. It is well to make match just for this purpose. The match should be made with several small strands of string rather than one large strand, and it should be well impregnated with powder, smooth, and stiff. Not only will this match be easier to insert thru the holes, but it will be less likely to go out since powder will be contained between the strands, not just on the outside of the match.

After the match has been threaded thru the holes, it should be secured by either squeezing the sides of the fuse gently with thin pliers, or by pounding the ends of the fuse gently with a small hammer. All that is required is to crimp the quickmatch and the fuse core into firm contact.

Blasting fuse may also be used for small shells in the same manner, but it has three disadvantages: it has no visible flame, thus making it difficult to see where the shell is, its small size (slightly less than 1/4") makes cross-matching difficult, and its wax finish does not allow a good seal with the shell case.

There are some simple things to remember regarding commercial time fuse. First, it should be stored in a cool, dry place. It should not be bent at sharp angles, or subjected to rough treatment. It is best cut with a sharp knife, using steady pressure rather than a "sawing" motion. The holes should be drilled with a sharp hand drill, slowly.

In the next article, I will present information on one method of actual shell construction. Included will be drawings of cross-matched time fuse which should help to clarify any ambiguity remaining. When properly done, a cross-matched commercial fuse is very reliable - this method is used almost exclusively for standard shells manufactured in this country.

BASIC SHELL CONSTRUCTION - PART III

by Bill Withrow

Most exhibition shells manufactured in this country are single-burst cylindrical shells constructed in a manner similar to the method ascribed to Italian pyrotechnicians and described in both Davis and Weingart. In this article, I shall briefly describe the variation of this method that I use. More details about the actual construction techniques, materials required, and sizes will be presented in subsequent articles.

The shell case is made from paper, cardboard, paper board, paste, glue and string. The basic shell case is one or two turns of thin cardboard, two to four turns of strong paper, and four discs of heavy paper board. The cardboard is rolled around a former (2½" in diameter for a 3" shell) and pasted at the end to hold it in place. The end of a piece of strong paper is pasted to the cardboard tube, about three turns are rolled (without paste) around the tube, and the end of the paper is pasted down. The paper is wider than the cardboard by an amount equal to the diameter of the former, with equal lengths of paper projecting over each end of the cardboard tube. This assembly is the body of the shell.

The ends of the shell are made from heavy paper board. Any paper board about 1/8" thick and reasonably stiff is suitable. Discs of this material are cut so they fit tightly inside the paper tube and rest on the cardboard tube.

The time fuse is prepared by cross-matching a 2" to 3" piece of it about ½" from one end. A mark is made on the fuse precisely 1" from the cross-match (with a pen) for future reference. The fuse is inserted through a 3/8" hole punched in the center of one of the discs and pulled through the disc so the cross-match rests on the disc.

The shell case is then pulled part way off the form and the fused disc is inserted into it (matched end inside the case). The disc is pressed down so it rests firmly on the inner cardboard tube, and the paper that extends beyond the disc is pleated down tightly on the top of the disc. Another disc with a hole in the center is passed over the fuse and pressed down firmly upon the folded paper. This end is the top of the shell.

The shell case is then removed from the form and filled with the desired mixture of stars and burst. With this type of shell construction, it is essential that the shell case be quite full, for it is the contents of the shell that provide, to a large extent, the strength and rigidity of the shell. The case really just defines the shape - it does not supply the strength. The case is filled to the top of the inner tube. A disc is then pressed down upon the inner cardboard tube, and the paper extending above the disc is pleated down upon it. Another disc is positioned over the folded paper.

(Ed. note: The reader is referred back to Part II of this series, Feb. 1969 issue, for a discussion of cross-priming and the preferable type of time-fuse to be used.)

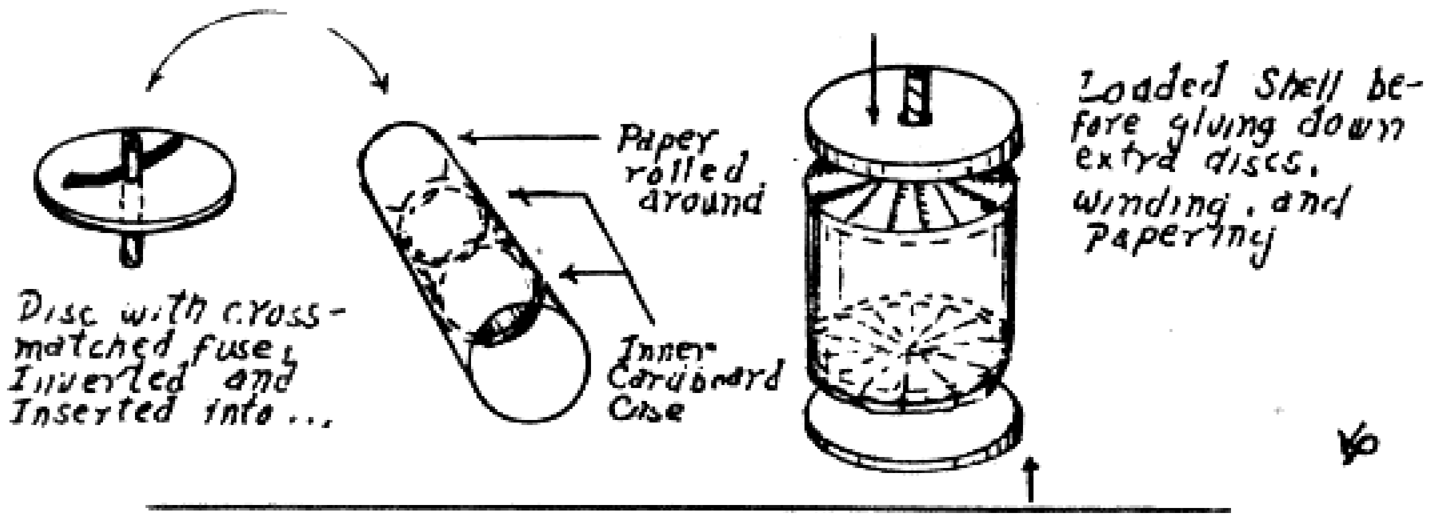
The shell is then ready to be wound. For smaller shells (e.g. 3" or 4") a single strand of ordinary cotton twine is used. For larger shells, two or more strands are used in parallel. A liberal application of a good grade of glue is made on the top disc against the base of the fuse and the winding is started by securing the end of the string snugly to the base of the fuse with the traditional fireworks knot — the clove hitch. A thick bead of glue is used so that the excess glue remains to seal the fuse, string and top disc together.

The string is then passed around the shell axially (or lengthwise), using only moderate tension on the first turn. When the string passes the fuse, it is bent around it slightly and wound around the shell again. After the first turn, enough tension is applied to the string to bow the edges of the outer discs into firm contact with the body of the shell. The winding is continued until the shell is uniformly wound with one layer of string. The distance between adjacent turns is kept as uniform as possible. The number of turns used depends on the size and type of the shell; for ordinary star shells, a string spacing of about ½" is quite sufficient.

When the axial turns are completed, the string is held against the edge of the shell with the thumb, and a loop is passed around the shell radially (around the circular way) so it crosses over the starting point. This loop is pulled tight, thus securing the string, and the shell is wound radially. Again, uniform tension and spacing are maintained. The string is then tied to one of the last loops. The winding is then complete — the strings forming a net-like covering on the shell. At this point, an additional layer of glue is often applied around the junction of the string and time fuse to insure a good seal at this point. The seal must be good or the shell may burst prematurely ("flower pot").

The shell is then "papered". A strip of strong paper is cut wide enough to project beyond the bottom of the shell by an amount equal to about 3/4 the shell diameter and beyond the top by about ½ diameter. This strip is covered with a good grade of paste, and about four turns are wound tightly around the shell. The paper is worked tightly around the shell with the hands. The projecting paper is then cut into strips about ½" wide and, with the liberal application of more paste, these strips are folded against the ends of the shell. The strips are worked firmly into position on each end of the shell with the hands.

It is especially important that the papering be close and tight around the fuse. The shell is then allowed to dry completely, after which the lift charge and quickmatch leader are attached and the shell is ready for use. These operations will be described in the next article, along with the details omitted in the general description above.


Paper rolled around
Loaded Shell before gluing down extra discs, winding, and papering
Disc with cross-matched fuse, Inverted and Inserted into ...
Inner Cardboard Case

BASIC SHELL CONSTRUCTION - PART IV

(Conclusion)

by M. P. Vander Horck

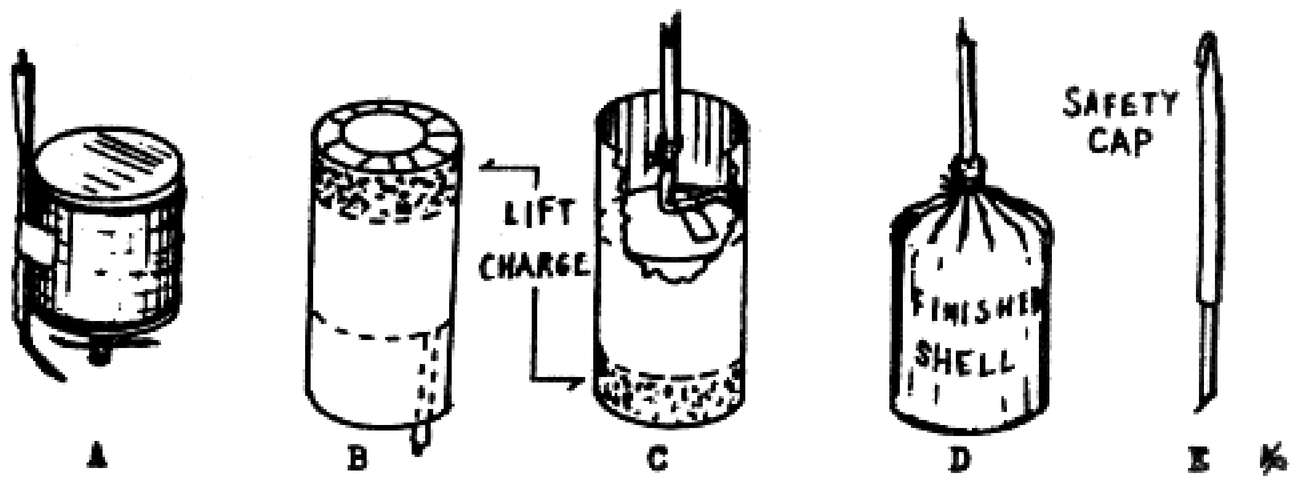
(Note: Part I of this series appeared in the January 1969 issue, followed by Part II in February and, after six months during which we received no further submissions, by Part III in August. These were all written by Bill Withrow and described the construction, setting and loading of mortars, various types of time fuses, cross-matching them, and finally the charging and fusing of a cylindrical shell up to a certain point. Because of another apparent breakdown in communications through the mail which we are at a loss to understand, nothing further has come in from Mr. Withrow, though he claims to have sent us Part IV over a month ago by certified mail.

Not wishing to leave our readers in the same suspense to which we have been subjected, we have modestly attempted to finish in this issue the shell which Bill started out to describe. From correspondence dating back to 1965, we think we have a pretty good idea of what he would have written for this part, though it is impossible to avoid the introduction of some of our own ideas into the text. We have called this the "Conclusion" of the series, because it wraps up the description of a simple single-break canister shell. Any further such articles will come under the heading of "Advanced Shell Construction", which we plan to cover next year.)

At the end of Part III, the shell had been loaded with bursting charge and stars and papered, with one end of the time fuse cross-matched and extending into the shell and the plain end protruding. A mark had already been made on this plain end just one inch from where the cross-match was inserted, so as to be visible outside the shell at this stage of assembly. Now another 2" to 3" length of black match is inserted through a hole bored or punched at this mark, so that the second cross-match will be just one inch from the one inside the shell along the length of the time fuse. This is about an optimum spacing; a slightly shorter one will cause the shell to burst earlier after it is propelled from the mortar, and vice-versa. Note: Careful preparation and installation of the time fuse is undoubtedly the most important point in shell construction from the viewpoint of safety and effectiveness. It must invariably be ignited as the shell leaves the mortar, burn with a predetermined speed and equally invariably ignite the bursting charge at the proper height, usually 3 to 5 seconds after being lifted. Thus this writer favors priming both ends of the fuse where the cross-match intersects it with black powder paste to insure positive ignition.

The next step is to attach a length of piped match to the side of the shell to convey fire from the top to the lifting charge. This should be of the best quality, whether commercial or home-made. A piece 7 to 8" long is taped to the side of the shell as illustrated, with ½" of the pipe extending below the shell and an additional 1" of bare match protruding, and about 2" of piped match above the shell. ("Below" here means toward the end with the time fuse, which will be on the bottom with the lift charge.) Before attaching the piped match, it may be helpful to lay it on a hard surface and flatten it slightly with a roller, to improve the roundness of the final shell. Now another piece of kraft paper is cut to a size big enough to wrap around the shell a couple of times and extend outward about three inches at both ends of the shell. The size for cutting these sheets for additional shells of the same dimensions can be determined after the following operations. The sheet should be wrapped and pasted down tightly over the shell and piped match, then checked against the mortar to be used for proper "windage". This means that the outside diameter of the shell and the inside diameter of the mortar should be such that the shell will slide freely without binding against the sides, but without so much clearance that it will rattle excessively when shaken. For a three-inch shell, the difference in diameter should be about 1/8" all around.

Now comes the placing of the "lift" or "blowing" charge, which should be about Fg or FFg black powder (as compared with FFFFg or finer for the bursting charge in the shell itself). Surprising-



ly enough, very little powder is required for the lift charge. The ratio by weight is only about 1/5 to 1/4 of that in the bursting charge. Withrow says he uses only about 3/4 ounce for a 3" shell, which lifts it about 500 feet.

With the shell inverted (cross-matched time fuse on top), the lift charge is placed in the open end and another disc just large enough to fit tightly inside the paper wrapping is pressed down firmly over the powder. The paper extending beyond the disc is trimmed if necessary, folded and pleated, and pasted down against the disc, after which a slightly smaller paper disc is pasted over the hole in the center. The shell now looks like "B" above (note that this is inverted from "A", which shows the piped match taped to the shell before the final wrapping). It is now turned over again and set on a flat surface for the finishing touches.

A longer piece of piped match with an inch of bare match exposed at one end is inserted into the pipe extending up between the shell and outer wrapping and the joint tied securely. Care must be taken here that the ends of raw match overlap and are in good contact, and if any paste or glue is used, none must get on the match itself. Now tape the piped match down to the center of the disc as shown in "C". The extending paper is then folded and gathered around the long piece of piped match above the joint and securely tied, as in "D". The top of the shell may be made as neat-appearing as desired, but the piped match must be firmly attached, since it supports the weight of the shell when lowering into the mortar. It must, of course, be long enough to reach the mouth of the mortar with at least six inches hanging over when the shell is at the bottom of the tube.

The paper tubing is carefully trimmed away at the far end, leaving 3 or 4 inches of black match exposed. The length of this part determines how long the operator has to retreat from the mortar after lighting the end of the match, as it will burn with moderate speed until it reaches the piping, after which the transfer of fire to the lift charge can be considered instantaneous. The burning time of whatever match is used should be carefully determined in advance and the exposed piece cut to length accordingly. A safety cap or sleeve must be made for each shell, closed at one end and having an internal diameter to just slip firmly over the piped match. This is slipped in place over the exposed black match and not removed until after lowering the shell into the mortar and just before firing. The purpose, of course, is to prevent ignition by stray sparks. This cap is shown in "E" and should be of different color than the piped match to advertise the fact that it is in place. Since the piping is generally tan, the safety sleeve could be white, which shows up best after dark.

As a final touch, each shell should be clearly marked with the bore of the mortar for which it is intended and the effect it will produce, for later identification; for example: "3-Inch Single Break Red & Blue" if it contains such stars. Avoid the temptation to call a 3-inch diameter shell "9-inch" or use such nomenclature as "Rainbow Shell", "Rose Bouquet" and the like. This may look fine in a catalog but don't tell the operator very much!

This article and the ones preceding it describe what is about the simplest construction for aerial shells, hence the name "basic". Even in the simple canister shell, however, there is one variation in fusing that should be mentioned. In such construction, all steps are the same up to the point shown in drawing "A", but at that point the shell is inverted with the time fuse thereafter at the top, so that it does not extend into the lift charge. Where the long piped match enters the shell, it is joined first to the time fuse and then to the shorter length running down the side of the shell into the lift charge. The advantage claimed for this method is that the blowing charge acts against the solid disc at the bottom and can not cause "blow through" of the time fuse and fire into the shell at the instant the lift charge goes off, causing a "flowerpot". This is seldom a problem, however, when the type of fuse recommended by Withrow is used and securely glued in place, though it may recommend itself for larger shells using the Roman or rammed type of time fuse.

The disadvantage of this alternate type of fusing is, that if the piece of match leading down to the lift charge should fail, the fuse of the shell itself has already been lit and it will certainly blow up in the mortar. The danger of such a failure is often lessened by running two lengths of match down opposite sides of the shell into the lift charge.

** ** ** ** **

FINAL NOTE: This series of articles was printed in AP with one objective — to acquaint the beginning pyrotechnist with the principles of aerial shell construction, in the hope that he will find such knowledge of value later in his career. It should not be taken as encouragement to the inexperienced to attempt such construction on his own, which would be dangerous and illegal! — Editor

THE RADIANT WHEEL

by MIKE GAGE

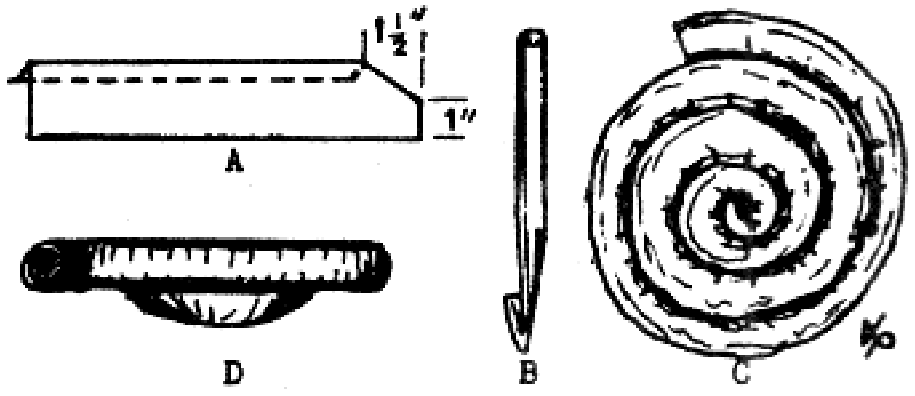
First mention of the fascinating "radiant wheel" appeared last July in my article on the Kandyan Fireworks Co. Since then, many readers have expressed a keen interest in knowing the details of constructing such a device, but they have remained obscure. At long last I have obtained the secret formula from Mr. J.W. Deenis, who got it from an old Chinese pyrotechnist in Calcutta.

Before this release to AP readers, both the formula and construction method were tested by Mr. J.B. Barkley of Hixson, Tenn., who found the results excitingly successful. In fact, he told this writer, "Success.. Success...Success...Success!!! Sweet Sulfurous Smell of Success! By the Great-Horned Deflagrating Spoon,...I've Done It! The radiant wheel worked!...I think Mr. Deenis' wheels are superb and I don't see how the Kandyan variety could be better." (Ed. note: all this fanfare concerns a tiny device only 1½" in diameter and about ¼" thick, but they say that good things come in small packages, so read on.) Here, then, is the information you've all been waiting for:

Formula	
Barium nitrate	16
Aluminum flake	4
Aluminum dust	10
Sulfur	2

(parts by weight)

The nitrate must be finely powdered.



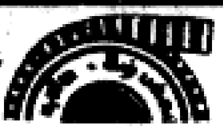
From a piece of shopping-bag paper (brown) cut a strip 8½" by 2 3/4" and cut off one corner about as shown in A. Fold back to form a ½" flap as indicated by dashed lines. Lay a rod 4 mm. (3/16") in diameter along the top and roll the paper toward you around it and downward, keeping it tight and pasting the last turn. When dry, fold up about ¼" of the end with the cut corner to seal this end and partially flatten about half the tube as shown in B. This makes a nice taper which aids in winding after the tube is loaded.

Ram the composition into the tube lightly, using a thin rod (a hard-packed tube would be impossible to roll up). This is facilitated by the use of a small funnel fitting the opening, or, as suggested by Mr. Barkley, the corner originally cut off can be pasted or taped around the top to act as a funnel, which is later cut off.

When nearly full, seal the end with priming paste or dextrin-water mixed with wheel composition (a piece of black match can be inserted as a fuse). Now begin at the tapered end and roll the tube into a tight serpentine, securing each wind with stiff paste as you go. Be sure to maintain a nice circular shape as you firmly form the turns, since an irregularly-shaped wheel will spin erratically. When done, the wheel should appear as in C. (Both C and D are drawn to actual size!)

FINISHING: A disc of colored paper slightly smaller than the wheel diameter is pasted to each side, leaving the last turn showing, which can be decorated with strips of colored tissue (optional). Now the SPINNER is glued to the bottom so that the wheel will spin freely and evenly. This is a little nub 5/8" in diameter shaped like a Volkswagen hubcap, made from a piece of dowel, plastic button, or pressed from cardboard. A side view of the finished wheel is shown in D and a bottom view at the right, below a label from the product made by the Kandyan Fireworks Co., showing the performance to be expected from a properly constructed wheel. When placed on a smooth, flat surface and lighted, it will spin violently with a sizzling whir, emitting a brilliant fan of sparks to a diameter of eight feet or more. We hope you enjoy this little jewel from the Far East!

ALIDON
RADIANT
WHEELS



"ZIPPER STARS"

by BARRY ROTHMAN

An intriguing effect can be achieved by binding star mixtures with a high grade nitrocellulose lacquer. I have achieved the best results with DuPont High Grade (ave. 13.35%N) Nitrocellulose, although a lower grade would probably work and might be more readily obtainable.

The NC powder should be mixed with a half-and-half ether-and-alcohol solution to make a thick lacquer about the consistency of molasses, or acetone can be used alone as the solvent. The lacquer is then blended gradually with dry star composition until a thick paste is obtained.

This paste is packed wet into thin-walled paper tubes, nominally about ½" diameter by 1" long, with the fingers or a spatula, with ½-inch length of stiff black match inserted nearly its full length into the composition before it dries. The stars must be dried until quite hard, which may take a full week at room temperature.

When fired from a Roman candle (fused end facing the propelling charge) these stars will, at mid-flight, frequently veer off at (literally!) right angles to the initial trajectory. The effect is particularly startling with comet type mixes. The erratic rocket effect is also spectacular when the stars are fired en masse from a mine. I have not tried these in a shell (there may be some detonation hazard from the high NC content).

The following formula for a "safe" flash-powder was submitted by Bert Lindsly, first subscriber to join the PGI, a recipe which he credits to Bennie W. Dalton of Hurt, Va:

Potassium nitrate, double-refined powder	--	4
Aluminum, German Pyro powder, 400-mesh	—	2
Flowers of sulfur (not sulfur flour)	—	1½

All parts are by weight. Here are some of Mr. Lindsly's additional comments regarding this formulation:

"For many years I have been looking for a noise-making formulation that was 100% safe in all possible ways. This one is 100% non-toxic, friction-free, and any acid present will not cause a reaction. With any given case size, this formula will produce an excellent noise with complete safety. The cases must not be charged over half-full. I have found the pyro aluminum supplied by CASECO to be superior to others, but they sell only sulfur flour, not the required flowers of sulfur. This can be purchased at any drug store. If at all possible, the double-refined saltpeter should be used. Granular saltpeter can be substituted with somewhat reduced effect (also sold in drug stores), but then the ratio should be increased to 5 parts and ground as finely as possible with a mortar and pestle before mixing."

COMMENT: We print the above formula without recommendation, except that it is probably safer than those calling for chlorate or even perchlorate oxidizers. We have, however, been able to detonate an almost identical composition to the above by mechanical shock, possibly due to impurities in the ingredients WHICH ARE ALWAYS A POSSIBILITY. Thus we strongly recommend that any mixture containing powdered aluminum, even with nitrate oxidizer, never be subjected to grinding, ramming, tamping or pressing, but mixed and handled only in loose form.

"THUNDERSTORM" A stunning effect can be achieved by linking packages of Chinese firecrackers with Ensign-Bickford 'Quarrycord'. (For those unfamiliar with it, this is multistrand black match loosely interwoven with wax-impregnated thread. It has a nominal diameter of 1/8" and burns about 1 foot per second, available from Ensign-Bickford, Simsbury, Conn. in 500-foot spools.)

"Unopened packages of crackers are pierced through the center (where fuses meet) with a large awl; the hole should be large enough to permit entry of a double strand of 'Quarrycord'. Double fusing is neccessary to insure ignition and prevent cut-off. The packages are simply threaded onto the cord. I have found 10-foot lengths the most practical to handle at one time, and they can be assembled in the field conveniently.

"For best effect, I usually drape the strands, snake-fashion, over a length of wire at a height of about three feet above the ground. The 'storm' can be further garnished by introducing heavier salutes on perpendicular fuse lines toward the end of the cracker strings.

"I first used this effect in a display of 1964, with 1000 packages of crackers discharged in about 40 seconds as part of the finale. 'Thunderstorm' invariably wins applause from that portion of the audience that have not lost all the fillings from their teeth!" --Barry Rothman

A BLACK-MATCH MACHINE

by ALLAN FIECK

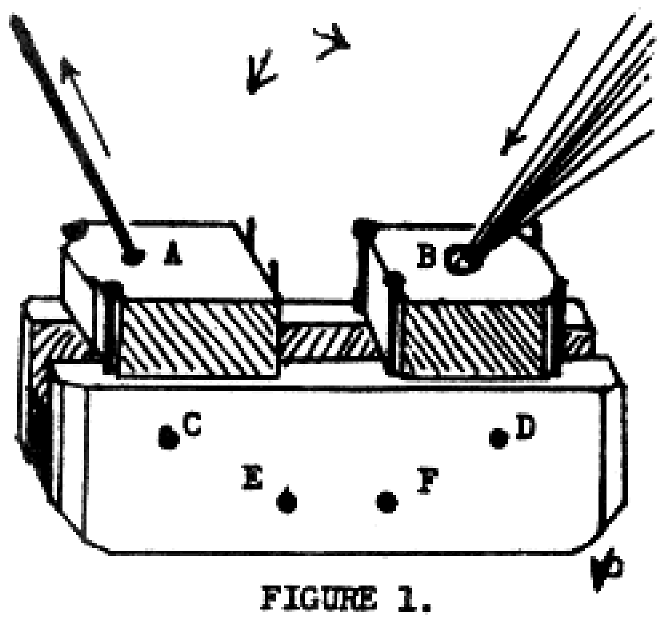


FIGURE 1.

The idea for this machine was conceived after a tour of Rozzi's Famous Fireworks plant in Loveland, Ohio. Their black-match machine was so beautifully simple that I tried using some of the principles in a version of my own. This is the result.

Figures 1. and 2. show the construction , in perspective and side-view cross-section and are rather self-explanatory, except for the following details.

The entire machine was made of hardwood and doweling and a few nails, to fit into a plastic container (not shown in FIGURE 1.). The one I used was 3½" wide, 5" long and 2½" deep, one of the plastic freezer containers readily available. FIGURE 2. shows how it fits into the container so that the composition surrounds the rollers. The dotted line represents the top level of the wet composition at beginning of operations.

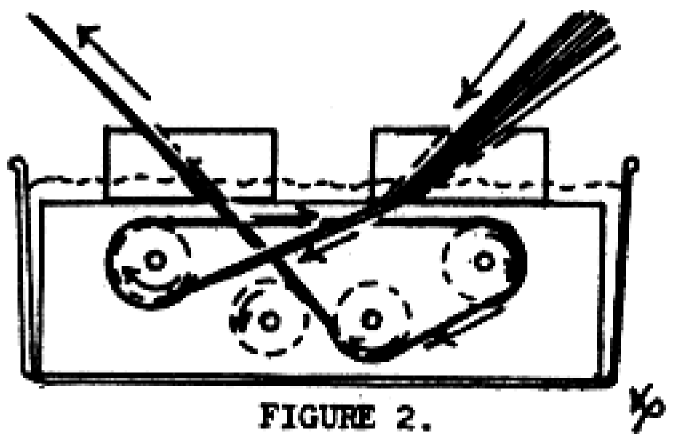


FIGURE 2.

For the rollers, indicated by C, D, E & F in FIG. 1, I used 3" lengths of 3/4" dowel with 5/16" holes bored through them lengthwise and supported by slightly longer ¼" dowels run through them and set into the frame as shown. Alignment of the frame is assured by a piece of wood fastened in each end, slightly longer than the rollers so that they may turn freely.

The two blocks A & B are loosely held in place on top of the frame by nails as shown in FIG. 1, to facilitate threading and cleaning, and are removable. They may be made of wood, plexiglass, or hard rubber for durability, as may the entire machine if desired.

Note that in the above drawings, the string that forms the core of the match enters the hole B at the right, which should be about 3/8" diameter (not critical), runs over and through the rollers and wet composition, and emerges through hole A, which is just slightly larger than the finished match, in this case a 1/8" hole. Note also that the holes are slanted in the direction of travel over the rollers, as shown in FIG. 2.

OPERATION: Begin with seven rolls of thin cotton string (not the waxed variety), arranged on a rack to the right of the machine so as to unwind easily. These are not shown in the drawings. Knot the ends together and pass them down through hole B, around the rollers as shown, and up through hole A. This can best be done while the framework is dry and clean. Now fill the plastic container half-full of wet composition (see below), place the machine in it, and add enough composition to thoroughly cover the rollers, as in FIG.2. Now grasp the knot extending from hole A and pull. By entering as seven individual strands and passing over the rollers, the string ends up evenly coated with compostion within and without and of even diameter as it emerges from hole A. This is greatly preferable to coating a single strand.

DRYING: The black cord which emerges is the finished match. It needs only to dry. As far as I know, my system for drying is unique. I use two 3-foot lengths of 2 X 4, into each of which I drive 17 large nails to a depth of about one inch, about 2" apart and in a straight line.

These are arranged in an equilateral triangle with the match machine as shown in FIG. 3, and all are fixed in this position by holding down with bricks or other devices. This is very important. Trying to work with poorly anchored equipment can be most frustrating. With the arrangement shown, you can make 170 feet of black match in about ten minutes. (For clarity, FIG. 3 is not drawn to scale, but shows only the first two strands of match looped around the nails.) The beauty of this setup is the equilateral triangle formed by the two 2 X 4's and the machine. This means that when you walk from the machine to an opposing nail, the length of match is automatically right. (It seems that the equilateral triangle has more uses in fireworks than for Ceylonese Firecrackers!)

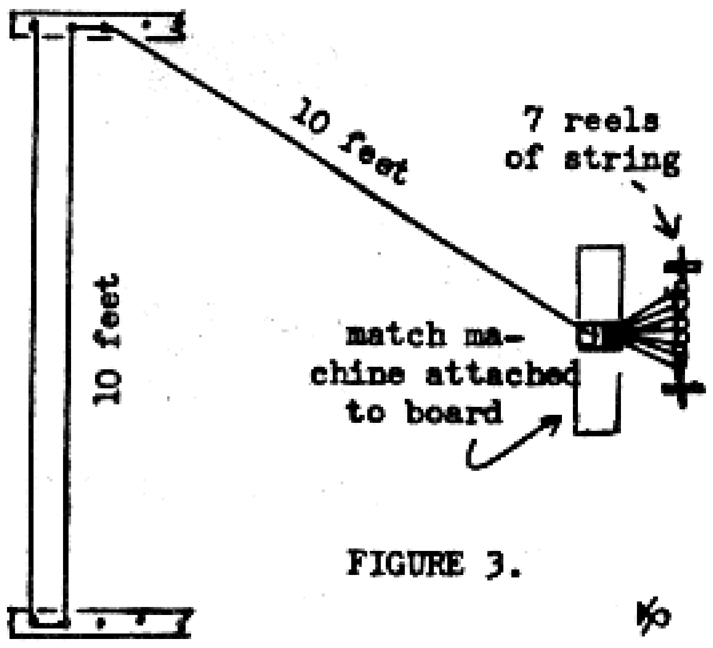


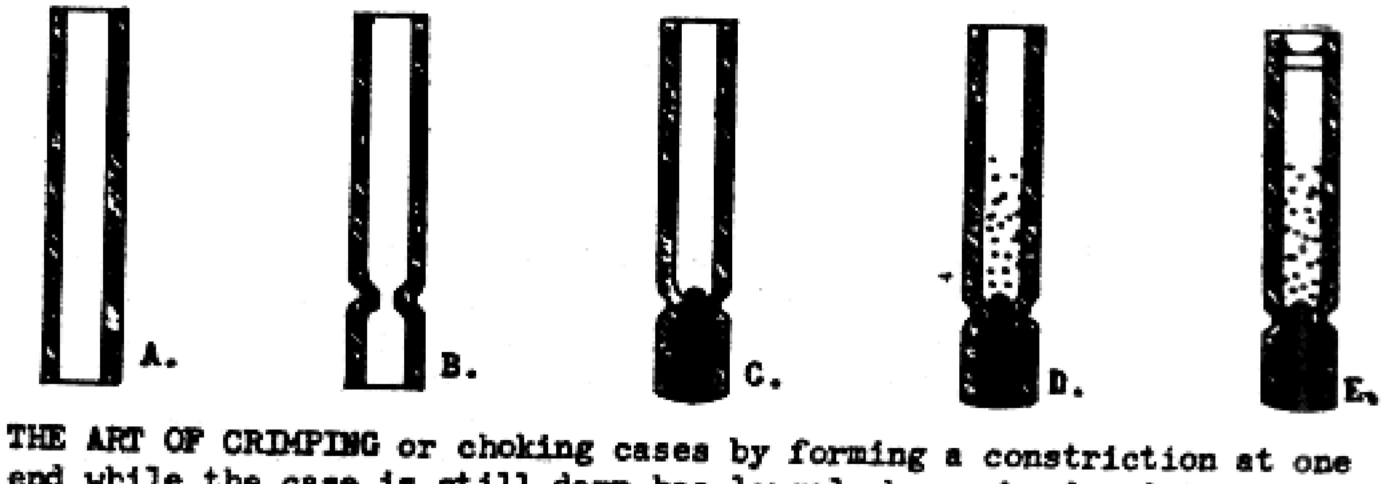
FIGURE 3.

Pull some of the cord out of the machine and walk to the farthest nail , hooking the knotted end to it. Bring the wet match down to the first nail in the opposite 2 X 4, around the second nail there, and back up to the first 2 X 4 as shown, until you have 17 strands of match hooked up for drying. The terminal end is knotted and attached to the last nail. The match emerging from the machine is also knotted for ease in starting the next batch.

Allow the match to dry about two days before using. It may then be cut into 2, 3, or 5 foot lengths, if desired. It is, of course, EXTREMELY FLAMMABLE and should be stored in fireproof containers away from heat or flame.

COMPOSITION: With home-made black powder, this machine will make excellent candle match, burning fairly slowly, and if coiled, enough heat to ignite stubborn mixtures. With commercial powder (FFFFg, for example) it will have enough power to eject a parachute, and quickmatch made by enclosing it in a paper tube about ¼" diameter will ignite a set-piece almost instantly. In both cases, about one to two percent of dextrin or starch should be added to the powder for adhesion to the cord. A representative formula for home-made powder would be: potassium nitrate, 15 parts; charcoal, 3 parts; and sulfur, 2 parts (by weight), with all ingredients powdered as fine as possible before mixing. Water should be added very slowly, with constant stirring, until a mixture is obtained that will adhere to the string and give a smooth coating as it emerges from hole A. The machine here described will then produce an excellent black match, suitable for many uses in fireworks.

CRACKERS

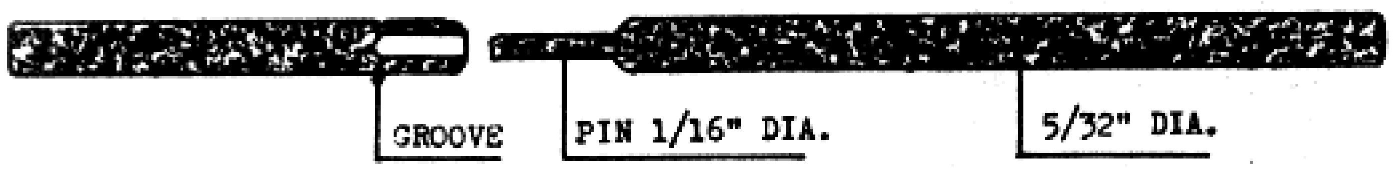


THE ART OF CRIMPING or choking cases by forming a constriction at one end while the case is still damp has largely been abandoned in the U.S. in favor of forming clay chokes by ramming. It can be used to advantage, however, with small cases to be used for crackers, serpents and squibs for either ground or aerial effects. In the latter case, especially, the reduction in weight by elimination of the clay is desirable. One of our correspondents in England, who will not permit himself to be identified otherwise than as "Ignis Fatuus" or "Will O' the Wisp" (figuratively, an elusive or misleading object!), has sent us the diagrams and suggestions showing a simple tool for forming such chokes, which can be made from a length of dowel. The cases may be rolled from 2" gummed sealing tape wound around similar doweling while well moistened, or around the tool itself. The soaped cord may be anchored at one end, with the other pulled firmly.

(A. Plain case. B. Choked while still damp, with thin cord soaped. C. Pressed into Meal Powder and Gum solution. D. After drying, with charge added. E. Card wad glued in.)

CHARGE: for flash report –– Pyro aluminum, 1, potassium perchlorate 2 parts by weight. Milder burst without flash — Grain powder FFFg.

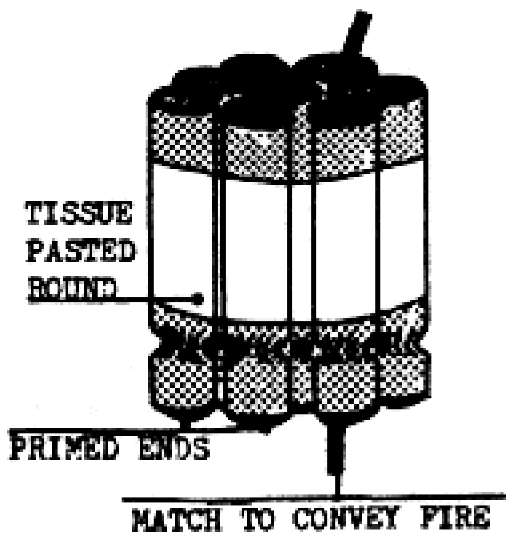
BELOW: FORMER FOR CHOKING DAMP CASING........



When the former, above is put together a gap will be left between the two faces to allow for the choke constriction. Groove is for locating case.

Where to use.

1.) Rocket heads, Shells or Mines, either alone or mixed with other stars.



2.) In bundles as shown on the right, for use in Candles. A bunch of crackers is made up to suit the bore of the Candle and a piece of tissue pasted round to hold them together for loading. The piece of bare match will ensure ignition of the blowing charge.

3.) Take a length of match and with pieces of Crepe self adhesive tape 1"x 1/4" stick the primed ends to the match about 1" apart. Hang up and light one end of the match standing well clear.

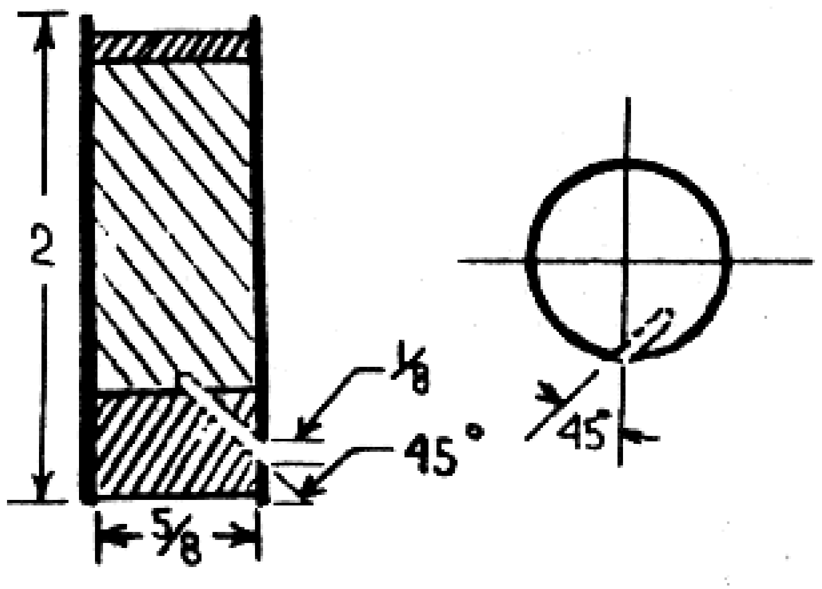
4.) Lay a length of Crepe self adhesive tape flat, tacky side up, run a length of bare match along it, longer than the tape allowing the match to overhang one end. Stick crackers nose to tail the length of the tape about 1/4" apart, roll up to form a long case with the match protuding from one end. Light the bare match and stand well clear.

F

THE WHIZZING ROCKET

by William Burklow

Here is an item similar to the commercial buzz bomb or buzz rocket, after which I designed it. The whizzing rocket is like a regular rocket except the nozzle is located on the side instead of the bottom, and it requires no stick or fins for guidance. When lit, it spins on the ground for a few seconds then takes off vertically, spinning and whizzing and giving off a circular array of sparks. It will attain an altitude of 50-200 feet depending on the angle of the bore.



First step is to make a tube 2" long with an inside diameter of 5/8". (A good tube can be made by rolling gummed tape around a 5/8" dowel.) Then pack about ½" of clay in the bottom of the tube and ram nearly full of rocket fuel (black powder). After sealing the other end with clay, a hole is drilled with a 1/8" drill bit into the bottom side, as shown in the diagram. The hole is drilled at a 45° angle upward, which gives lift to the rocket, and 45° off center toward the wall, which gives it its spin. The hole should be low enough on the wall to pass through the clay plug. The effects of this device are quite good in the daytime but even better at night.

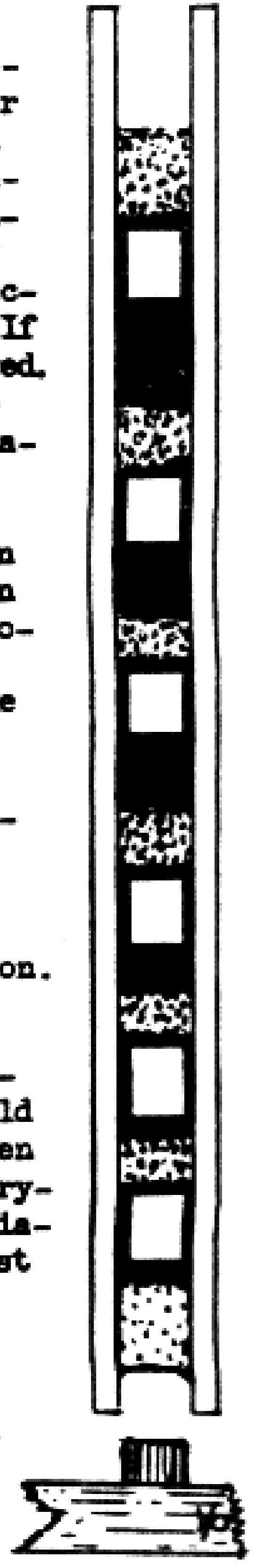
(Ed. note: Mr. Burklow did not specify whether the device should be stood on end or laid flat before lighting, but it would probably end up in the latter position anyway. Also, we don't quite see why it could be depended upon to rise "vertically" rather than take off at an angle. In any case, it might be prudent to use a long fuse and hide behind a tree after lighting!)

ROMAN CANDLES

by Reverend Ronald Lancaster*

Good roman candles are very difficult to make, mainly because there are so many factors which play an important part, and one or more of these can go wrong.

In the first place, a good quality of fine grain gunpowder should be used to eject the stars. In England we use grades F or FFF; i.e.: 16-24 mesh and 24-70 mesh respectively, which are known as C grade powders, representing about three hours milling in the initial stages. Powders which are faster or slower will cause the stars to be ejected either too quickly or erratically.



Next we must consider the tube. To start with it should have a thick wall, 3/16" or ¼", or it is likely to catch fire and burn if it is fairly long. The quality of the paper also plays a part; if a cheap "common" or "sugar" paper is used, it will burn away inside the tube and compression will be lost. On the other hand a good quality paper, rolled with a tough adhesive, hardly burns at all and the compression is too great. In this latter case the stars blow out with such violence that they are extinguished. In practice we use the cheap paper and a good quality gunpowder. If good quality paper is used, a weaker powder must be employed.

Another point to watch carefully is that the inside lap of paper in the tube is well stuck down. When tubes are machine-rolled, the paper is initially held onto the mandril by pushing the edge into a groove on the mandril, but the part which was in the groove frequently does not stick down after removal from the machine. If this happens, the grain powder creeps down under the loose lap causing a "blow-through" and the candle performs more like a machine gun. The best tubes are hand rolled, which is not difficult, but the paper does require careful pasting and the tube must dry slowly or it will warp, often ending up banana-shaped.

The bore of the candle is quite important also. Exhibition candles are best made in 5/8" bore tubes, mainly because the large stars give a good burning time; they can afford to burn a little in the tube, and the measures of grain powder are large enough to permit measurable variation. Candles of smaller bore than this tend to eject stars erratically and the stars soon burn out.

The stars should be of such diameter that they will comfortably slide down the tube. Under no circumstances should they be too tight or slack. Assuming that the tube has been rolled on a 5/8" former, it will shrink very slightly on drying, as will also the stars. Cylindrical stars 9/16" in diameter and ½" long when damp, pumped quite hard, will be just about right when dry.

(Note: Proportions in the drawing at the right have been exaggerated for clarity, including clearance between stars and tube walls and the amount of blowing charge under each star. The lighter spaces between stars represent slow-burning delay fuse or "candle comp".)

There are many theories about roman candle fuse (also referred to as "candle comp" and sometimes "dark fire"), but the important thing is that it should be dense and consolidate well. In order to achieve this object there is a tendency to incorporate a goodly quantity of potassium nitrate and sulphur. Too much charcoal makes the fuse too light and dirty to handle. The composition is used dry in England, and one can only assume that the American practice of dampening it is for the purpose of granulating it to reduce the dust or to make it move easily in the measuring-boards for mass filling.

The burning speed of the star is also important, and two techniques are used in relation to it. The better method uses very fast-burning stars and surrounds each star with a small charge of gunpowder to make sure that it is ejected immediately. With this method, it is important that the star burn rapidly; otherwise it will be extinguished as it is ejected. The second method uses no powder around the star, but slower-burning stars are employed which actually burn for a second in the tube before being ejected. Gas is lost up the side of the tube around the star and the latter is not blown as high as with the first method; moreover, the stars are ejected somewhat unevenly. A good candle should propel all its stars to the same height. To illustrate the variation in formulas for a "slow" and a "fast" star, note the following for a red star:

	SLOW	FAST
potassium chlorate	64	70
strontium carbonate	19	15
red gum	13	10
dextrin	4	4
fine charcoal, 150#		1

The manufacture of a 12" candle according to the "better method" noted in the preceding paragraph would take place as follows:

The tube is placed on a small nipple and a charge of clay poured in and consolidated by means of firm blows on a drift which slides easily down the bore. A charge of about 0.45 gm of F grain powder is added, then a star placed on top of it, making sure it goes all the way to the bottom. A charge of meal gunpowder, preferably grained, is poured on top of the star (about 0.50 gm above each star after it is inserted), and the tube is tilted slightly backwards and forwards to allow the powder to trickle down around the star.

Next a scoopful of candle fuse is placed in the tube and consolidated with blows from a light mallet on the drift. It should be noted that this is where the skill of a good candle maker lies! If the candle comp or delay fuse is consolidated either too heavily or too lightly, there is a tendency to get the "machine gun" effect. The drift needs to be tapped quite lightly and only experience will help here. (Too sharp a blow may crack the star and too light a one will leave air spaces between grains, in either case an invitation to undesirable explosive effects.) The following formula for candle comp is typical, about 4 gm of it being loaded above each star:

potassium nitrate	50
mealed gunpowder	22
charcoal, 40/100 mesh	11
charcoal, 30/60 mesh	11
sulphur	6

The foregoing steps are repeated for each of the half-dozen or so stars this length candle will accomodate, except for the following:

The charge of grained gunpowder below each star is increased from bottom to top of the tube; this is neccesary to insure that all stars are propelled to substantially the same height, as the first ones ejected have much less distance to travel through the tube with gas pressure behind them and would have less "muzzle velocity" if all propelling charges were equal from top to bottom. A charge of 0.45 grams was specified under the first star to be loaded. From bottom to top, the remaining charges should be about 0.55, 0.60, 0.90, 1.20 and 1.50 gm. If a quantity of candles are to be made in this size, it would be helpful to make separate scoops holding the appropriate amount of powder and numbered for each star. Separate scoops could also be made for the half-gram of meal powder to go above and around each star and for the 4 grams of delay fuse between each two stars.

(For the benefit of readers unfamiliar with the manufacture of "pumped" cylindrical stars specified in the foregoing article, a hand tool can be made consisting of a short length of brass or other non-ferrous thin-walled tubing with an inside diameter equal to the o.d. of the star and affixed to a substantial handle to fit the palm. A solid piston slides smoothly within the tubing and has a pin which projects through a slot cut in the latter, just long enough so that the piston is flush with the open end of the tubing at one extreme, and at the other it withdraws to leave a recess equal to the dimensions of the star — in this case ½" by 9/16". With the piston withdrawn, the pump is pressed into the damp but firm star composition like a cookie-cutter, filling the recess. Then it is placed against the drying-tray, the projecting pin pressed down, and at the same time the tool is lifted, depositing a smoothly-formed star. The author's specification, "pumped quite hard", presumably refers to the amount of pressure applied to the projecting pin before the tool is lifted. The coordination of these movements requires a little practice so that the star will not come out barrel-shaped or otherwise deformed.

There are, of course, machines which will produce pumped stars in quantity and good dimensional stability, as described by Weingart and others. For other colors than the red star mentioned above, the author suggests the following, contributed by him for Dr. Harbert Ellern's MILITARY AND CIVILIAN PYROTECHNICS, page: 368:)

	BLUE	GREEN	YELLOW
potassium chlorate	68	30	—
potassium perchlorate	—	—	70
barium chlorate	—	55	—
red gum	—	10	6
shellac	—	—	6
colophony resin	6	—	—
charcoal, 150 mesh	—	5	—
dextrin	4	(4)	4
sodium oxalate	—	—	14
Paris Green	22	—	—

GOLD: mealed gunpowder 58, lampblack 14, charcoal, 150 mesh 21, black antimony sulfide 7, dextrin (7)

WHITE	
potassium nitrate	51
sulphur	18
meal gunpowder	15
antimony metal powder	10
charcoal, 150 mesh	3
dextrin	3

SILVER	
potassium chlorate	60
aluminum, "bright"	20
" , dark pyro	20
dextrin	(6)

Note: All the above formulas total 100 parts each by weight, with the exception of the binder (dextrin), which is in excess and printed in parentheses where such is the case. Thus the measurcments can be taken either as "parts by weight" or percentages by weight. Three "Specialty Stars" that will also be of interest to the reader are included from the formulary referred to:

	ELECTRIC STREAMER	WHITE GLITTER	YELLOW GLITTER
aluminum, "bright"	—	8	7
aluminum, dark pyro	18	—	—
mealed gunpowder	—	66	70
charcoal, 40/100 mesh	20	—	—
dextrin	7	4	5
strontium oxalate	—	8	—
sodium oxalate	—	—	10
potassium nitrate	40	—	—
sulphur	10	—	—
black antimony sulfide	5	14	8

"Colophony resin" is common pine resin. Suitable neutraliser if required would be barium carbonate, 1% being adequate. All gunpowder-type stars are filled with a small charge of powder on top of the star.

** ** ** ** **

In the foregoing article, all remarks in parentheses are those of the editor. We have a few more in conclusion. The most frequently encountered roman candles sold to the public in America are of smaller bore and greater length than the type described; the stars generally are ¼" or 3/8" in diameter, with at least ten in a candle. Moreover, they are "mass-produced" on machines which can handle up to 12 dozen at a time. Concerning this method, Rev. Lancaster states in the chapter on fireworks which he wrote for MILITARY AND CIVILIAN PYROTECHNICS (and which he has generously expanded in the foregoing article for AMERICAN PYROTECHNIST), "The writer has observed the great force used with gang rammers in some fireworks plants and is not surprised that explosions have taken place with their use."

If the star compositions noted here are mixed while damp, with the oxidizer added as the last step, there should be no undue hazard. It should be noted, however, that the dried stars containing chlorates are later charged into the candle intimately with the "candle comp" and black powder, both containing sulfur, which is another reason for using only the "gentle consolidation" recommended by the author.

Roman candles are something of an oddity in fireworks, and their origin is in question. The only reference to a similar item in antiquity seems to be the ancient Greek Fire, where balls of flaming fuel and oxidizer propelled themselves from a tube or gun by the pressure of their own burning gases. The present-day firework might therefore have been called Greek candle, since there is no evidence of its having originated in Italy. Whatever it is called, the roman candle has become a traditional part of the fireworks scene, both for exhibitions and for public use (except where laws prohibit "any item of fireworks that discharges balls of fire into the air"). It is beautifully effective and essentially non-annoying, since the only noise it produces is the "phutt" as each ball is ejected, hardly detectable at any distance.

It is hoped that the information given in the Rev. Lancaster's article as to the techniques and tricks of the trade used in making roman candles will be of interest to all readers, and it should not be overlooked that the star formulas given are equally adaptable to use in floral shells, rockets and mines.

A PYROTECHNIC PAPER CUTTER

by James R. Buja

A simple and inexpensive device for accurately cutting paper for pyrotechnic items has long been missing from the pyrotechnist's workshop, but the need for one has been demanded by many types of fireworks that require dimensional accuracy. Now, with the presentation of the Pyro. Paper Cutter, one can avoid uneven, unsquared, or jagged edges when cutting his paper, with a gain of accuracy and efficiency.

Basically, the Pyrotechnic Paper Cutter is a device for:

1) accurately measuring and squaring almost any size paper
2) holding this paper securely
3) cutting it accurately and efficiently
4) cutting large quantities of paper to the same size
5) creasing paper in preparation to folding it.

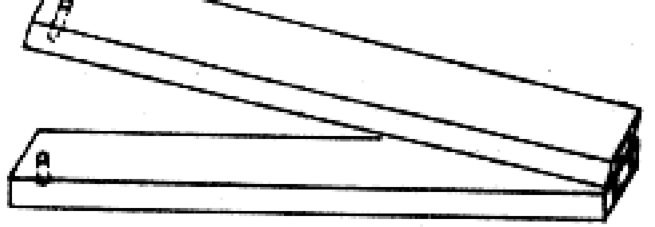
MATERIALS

2 boards 30" x 1½" x 3/4"
1 board 30" x 1" x 3/4"
1 board 29-3/4" x 12" x 3/4"
1 board 4" x 1½" x 3/4"
1 board 1-3/4" x 1" x 3/4"
2 masonite strips 4" x 1½" x ¼"

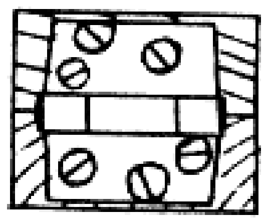
1 steel strip 36" x 1/8" x 1"
1 heavy steel strap hinge (3" straps)
1 utility hinge (1" wide)
1 2" x 20 bolt & nut (¼" dia.)
1 heavy-duty utility knife razor
4 sheets of ¼" division graph paper

Flathead woodscrews, masking tape, glue, sheet metal screws, rubber, 2 12" rulers, ¼" x 20 tap, ¼" rod.

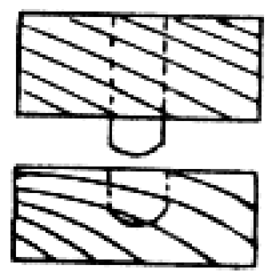
CONSTRUCTION



P.P.C. without Grid-board



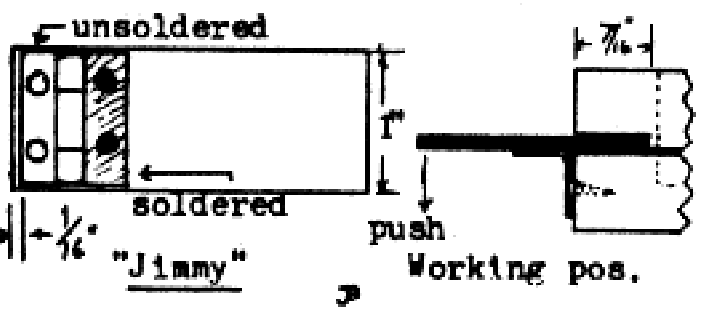
Hinge view



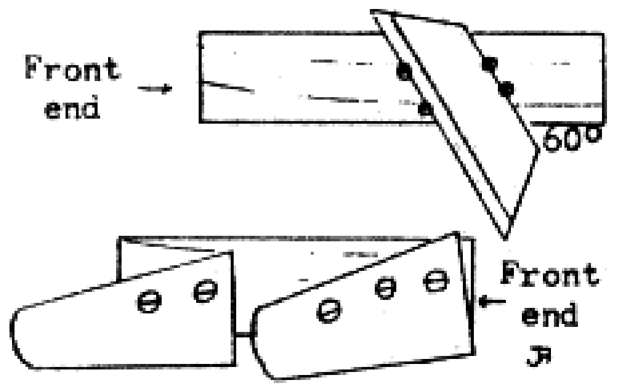
Front end

THE CLAMP: Start by cutting off 2¼" from each "strap" of the 3" hinge. These pieces are to be used on the cutter block later. The hinge is now attached with the screws supplied with it to the two boards 30" x 1½" x 3/4". Four more holes must be drilled in the hinge to add needed stability to the clamp. It's also a good idea to hold the clamp in a vice when drilling the pilot holes and attaching the hinge.

To keep the clamp closed during cutting operations, a 1-1/8" by ¼" dia. rod or shank of a spike is secured in the upper clamp section by drilling a hole with less than a ¼" drill bit then enlarging it until it forms a tight, permanent fit with the rod. A ¼" drill bit is used to form the "female" hole in the lower board and is enlarged slightly to form a semi-permanent fit. Thus, when the clamp is closed it will remain this way until it is pried apart.

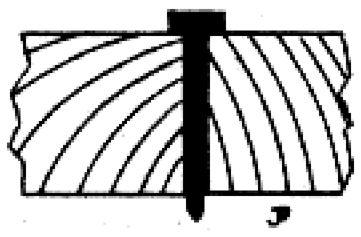


THE "JIMMY": In its simplest form, it can be a thin screwdriver inserted into the end of the clamp to pry it open. However, a more professional job can be made using the same principle, but in a permanently attached form. Cut a 2-3/8" piece of steel strip and solder a 1" hinge to it. (see fig.) The upper clamp must be grooved to accommodate the added thickness of steel strip (1/8"). Pushing down on the metal strip will open the clamp sufficiently to release its hold on the paper.

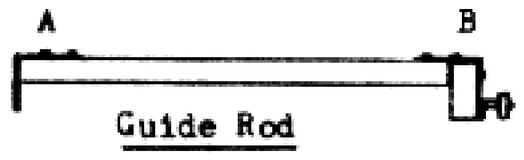


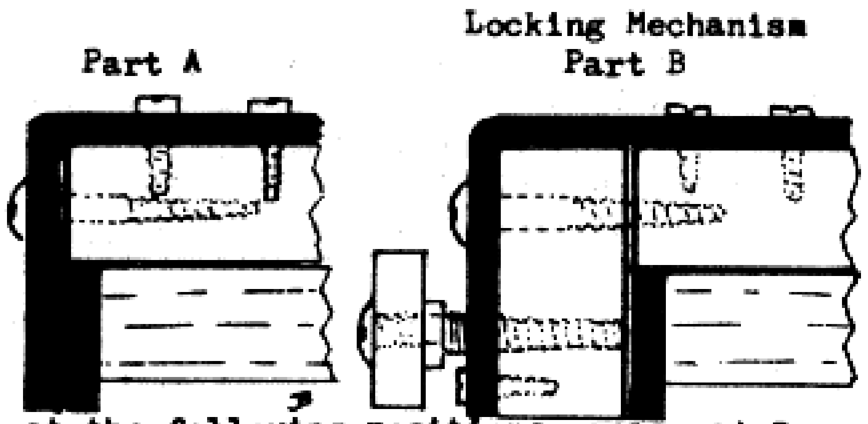
THE CUTTER: A few extra holes must be drilled in each section of strap that were cut from the 3" hinge. The sections should extend about ½" below the bottom of the cutter-block and also trail about 1" behind it. The opposite side has a "utility knife" razor (Stanley Heavy Duty @ 59¢/5 blades) attached with small sheet metal or wood screws. As a finishing touch, a handle can be attached to the cutter. This will help keep fingers away from the blade.

MEASURING BOARD: This is made from the 29-3/4" x 12" piece of wood. From the 36" (initially) steel strip two 12" pieces are cut and attached to the sides of the board flush with the top using epoxy glue. The whole board is attached to the clamp using masonite strips, steel strips or mending plates. The board should be attached between 1/16" and 1/8" away from the clamp. (see figure) Two small nails can be used as separators to achieve the same width slit along the two boards.



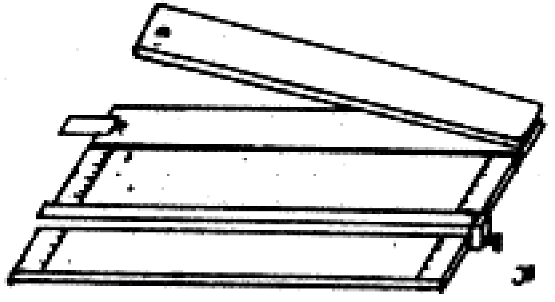
GUIDE ROD: This can be made from the same stock as the clamp but need only be 1" wide and 30" long. It must be about ¼" longer than the measuring board.





A piece of wood--preferably hardwood--1-3/4" x1"x 3/4", is attached to the 30" "rod" in the following manner. 2 four inch strips of steel are drilled five times, at the following positions, measured from the bottom. ¼", 5/8", 1-3/8", 2-3/4", 3-3/4". In one strip omit the hole 5/8" up. In the strip with this hole should have it drilled with a 11/64" drill bit in preparation for tapping the threads. The other holes will depend on the size of the screws that are used. When this is completed, the strips are bent to right angles 1-3/4" from the bottom. A thin piece of rubber should be glued as shown in the figure. This completes the guide rod.

RULERS AND GRID: Three sheets of ¼" div. graph paper are trimmed to proper size and pasted onto the measuring board. It should be positioned so that the graph paper ends exactly where the cut edge of the paper in the clamp begins (see figure) Two thin rulers can be glued to each end of the measuring board as pictured. This means that an equal thickness of wood on the guide rod at those positions must be sanded or filed away. The guide rod must be touching the graph paper at all points. Otherwise, the paper may slip underneath the guide rod, defeating its purpose. Note: the quarter inch marks on the ruler should match up with those on the graph paper. To increase accuracy, a single large piece of graph paper can be attached to the measuring board--if such a piece can be gotten.

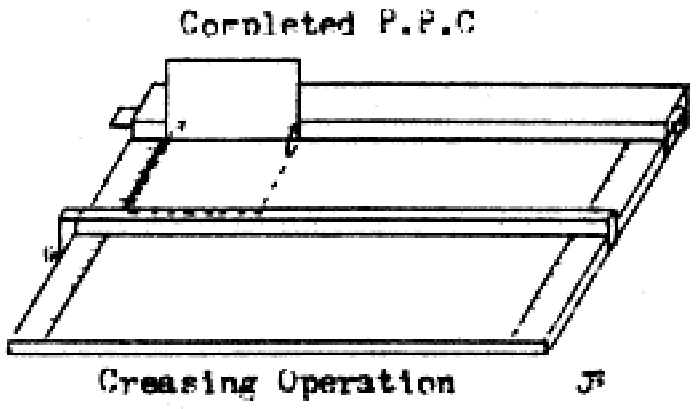


OPERATION

The piece of paper to be cut (such as kraft paper) is inserted in the clamp. It is then adjusted by pushing it against the guide rod and lining it up with either the edge of the ruler or one of the grid lines. The clamp is closed. If the paper is not held firmly in all places, strips of masking tape can be put along the inside, upper and lower edges of the clamp. Next the cutter is placed on top on the clamp and is pushed down it thus shearing off the measured section of paper. More than one thickness of kraft paper can be cut at the same time to increase efficiency.

CREASING: If a fold must be made in the paper, measure off the length of the fold using the grid. Close the clamp and push the paper up, perpendicular to the grid board, making the paper form a right angle. Then the paper is taken out and folded along this crease. (see figure)

Completed P.P.C



Creasing Operation

(We thank Mr. Buja for his well thought out and illustrated article and for the time he took to prepare it. He also made us up a prototype of the paper cutter, and it really works!

In case other readers might want to take advantage of our inherent laziness by preparing ready-made copy, the following details should be noted: Each page should be exactly 6 7/8" by 10 5/8", single-space typed with a good black ribbon on clean white paper, leaving 5/8" margin at each side and 3/4" at top and bottom. The paper need not be high-quality bond, but very thin ("onion-skin") stationery and the so-called "erasable" typing paper should be avoided. For illustrations, a medium-point ball-point pen with black ink, or a good black pencil (about #2, well sharpened) is excellent, but avoid colors, especially light blue. Do not attempt graduated shading, only line drawings, and avoid very fine lines, since they may be lost when the master is reduced to 80% original size in reproduction. Do not paste on any photographs. We will be glad to answer any questions for your guidance, and in all cases, be sure to query us about the subject and length of your submission before going to the trouble of preparing it.)

THE MAGNESIUM BOTTLE ROCKET

by John F. Glisson

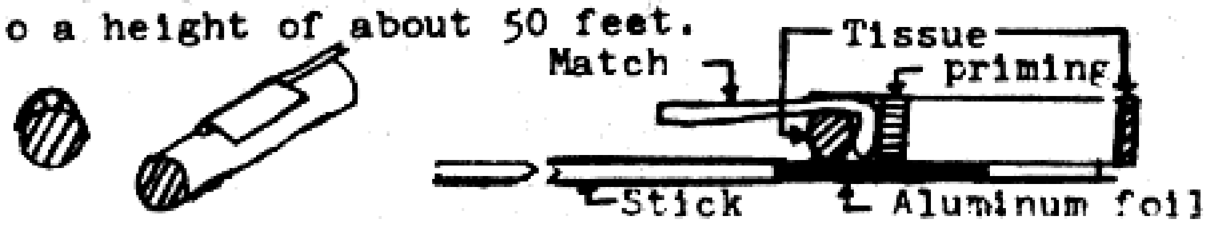
The purpose of the Magnesium Bottle Rocket is to provide variety of effect and color to the standard charcoal type. It consists of a very thin casing filled with a fast-burning Magnesium fuel. It can be used with or without a stick, the latter case being in shells or mines. When constructed as shown there is no danger of explosion since the powder is well-packed and the thin casing is consumed as it burns.

For the various colors, I recommend the following formulas. NEVER mix more than 5 grams of powder at a time since the fuel is very fast burning but safe to mix since it contains only Nitrates.

Weigh in grams:	(RED)	(GRN)	(BL)	(YEL)	(OR)	(W)	(PUR)
Pot. Nitrate			1	1	1	1	
Barium Nitrate		1					
Strontium Nitrate	1						1
Paris Green			¼				¼
Sod.Carbonate				¼			
Magnesium Carbonate					¼		
Magnesium powder(100mesh)	1	1	1	1	1	1	1
Dextrin	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Color intensifier (PVC)		1/8	1/8				1/8

The casing can be made out of Kraft paper. It should be about 1¼" long with the inside diameter about 3/16". It should be dry rolled 4 turns applying Sodium Silicate to the last ½ turn to hold the casing. Let dry for 5 to 10 minutes. To load the casing, first ram a small piece of tissue paper in the bottom so that it completely covers the bottom hole as shown below. This should be done on a flat surface. On top of this, ram the fuel firmly until the powder level is ¼" from the top. Above the fuel, ram dry priming 1/8" thick. Then insert a piece of bare match as shown below with a wad of tissue paper to hold it in place. When this has been completed, dip the tip of the casing with the rammed tissue paper in Sodium Silicate to secure it. Let dry for 10 minutes. This acts like an endplug. The stick used must be very strong and thin to keep from burning up. The stick can be made out of Bamboo, about 8" long. It becomes helpful to wrap 1 turn of Aluminum foil around the stick next to the casing. Attach stick to casing by overlapping a small piece of paper over the stick with Sodium Silicate onto the casing as shown below.

Fire the Magnesium Bottle Rocket as you would a normal bottle rocket. It burns with a brilliant flame, giving a fireball effect of whatever color used. It will burn to a height of about 50 feet.



THE CHEMICAL TUMBLER

by James R. Buja

INTRODUCTION:

There is not a Green Man who would claim that he enjoys mixing chemicals; dusty, dangerous, or otherwise. I doubt that anyone who has ever used a chemical tumbler (also referred to as a "Ball Mill") would revert to mixing dry chemicals. A tumbler is truly the best worksaving device you could have. A commercially built tumbler is costly, but the homemade machine featured here should cost no more than five dollars, not including the motor.

I got the idea for mine from Alan Grimwood. The basic setup is used in all commercial tumblers. This is; a motor drives a cylindrical rod, and this rod transmits the motion, at reduced speed, to the mixing drum. Thus the chemical is tumbled constantly along with metal or other hard balls until pulverised to a finely divided powder. In another operation a mixture is simply incorporated using soft balls.

The power source is the most expensive part, but can often be obtained from a discarded appliance which is motor driven. I've even gotten word from Mike Gill that a can opener motor will work. With certain appliances, you may be lucky enough to get the pulleys and belt needed, meaning considerable savings.

The cheapest material for the drive rods would be a wooden dowel. However, it would be difficult to obtain the right size dowel (greater than 1") and perfectly center the four axles. This second point is absolutely necessary if the tumbler is to be relatively vibration-free. Since I preferred a tumbler that would use standard parts available to everyone, I chose a ¼" dia. steel rod. The rod itself is the axle, thus eliminating one more chance for an error.

In answer to the question of "What will the rods rotate in?" I came up with a method that is cheaper by far, than a pillow block, and gives very satisfactory performance for its simplicity. This is an eye-bolt (fig. 2) in which the loop is evidently formed by bending a piece of rod around a ½" former. Thus there is just enough allowance so that the drive rod will rotate smoothly and quietly. Because of the small diameter of the rod and its fast RPM (500) I've added some "rubber washers" (for lack of a better name) to the rods (fig. 1 & 3) so that more traction is produced. In addition to this, most of the smooth surface tumbler drums will need about an inch wide strip of rubber around each end. Fortunately, with smaller cans, such as coffee cans, there is enough traction from the washers so the rubber strips are not needed. In the list of materials almost everything should be readily available from the hardware store and service station.

2 pulleys (see text for sizes)
1 36" steel rod
4-8 rubber washers
4 eye-bolts (3 x ¼") (Fig. 2)
4 ½" I.D. metal washers
10-12, ¼" I.D. nuts
2-3 ¼" I.D. wing nuts

3 cotter pins (fit 3/32" hole)
1 V-belt (#2260 or larger)
1 rubber tube (or strips 1" wide)
1 base--16 x 13 x ¼ (also see text)
12-14, ¼" I.D. metal washers
2-3 carriage bolts (3½ x ¼")

1 Electric motor (1/6 HP is O.K.)

For my own model, I find that a 6" can rotating at 90 to 100 RPM is sufficient when the can is about ¼ full. 75 RPM is best for heavier loads which may take up half of the can. To achieve these speeds, I use the following pulley combinations--the smaller pulley of each set being the one for the motor shaft.

90-100 RPM: 2" / 3½"   75 RPM: 2" / 4"   (using an 1140 RPM motor)

No doubt the reader can estimate the approximate size pulleys for his own particular machine. Remember that the smaller pulley should be the smallest diameter possible since a proportionately smaller pulley can then be used for the second one. You may find a 3 or 4 step pulley to be convenient for quick changes in drum RPM.

CONSTRUCTION:

Enough clearance must be allowed between the large pulley and the base. Using a base thicker than ¼" would cause the eye-bolt to set too low to base. The drive rod would then be too close to the base, leaving insufficient space for the pulley to rotate. Therefore a ¼" thick base is preferred. I used ¼" Plexiglas, since it is fairly incompressible, meaning the eye-bolts won't loosen up. However, another alternative for the base is given in figure 4, using countersunk holes (to ¼" from the top surface) so a thicker base can be used.

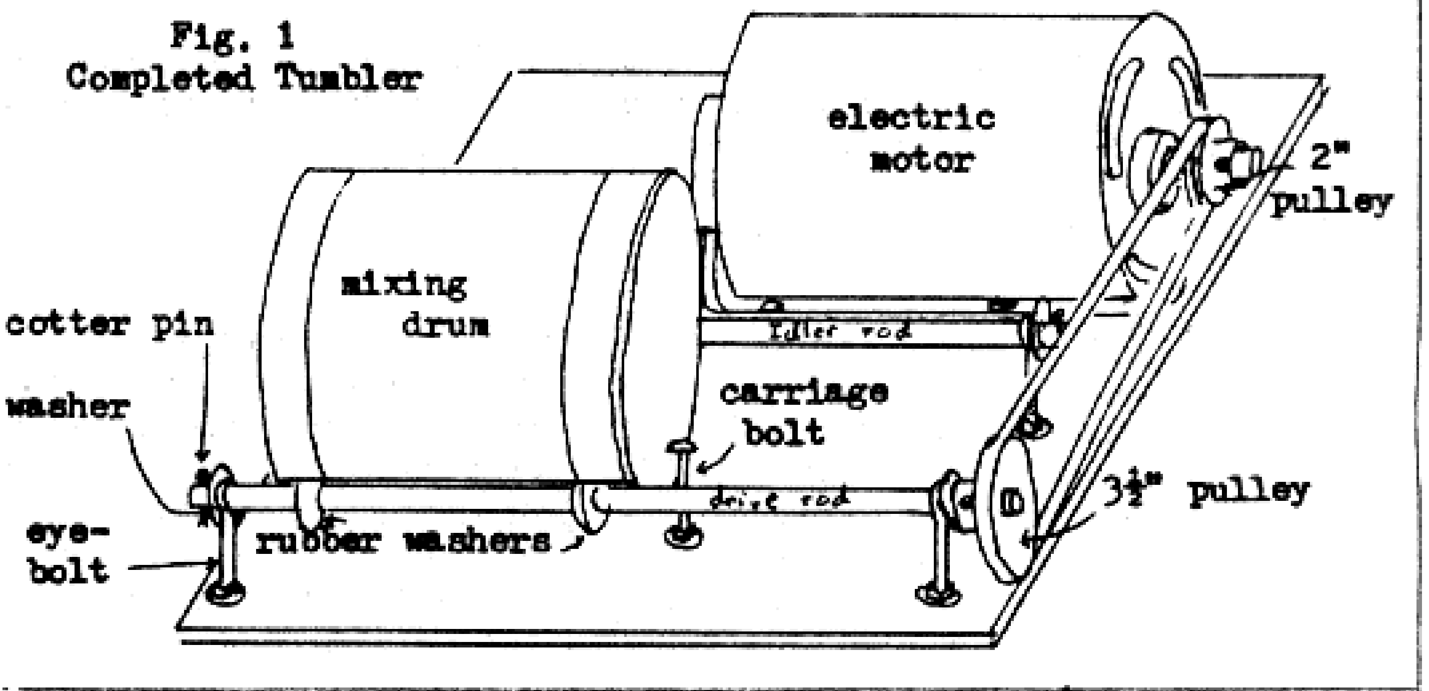
The holes are drilled for the eye-bolts (Fig. 5) and these bolts are attached according to Fig. 2, making sure all the eye-bolts are the same height. The top of the bolt should be 2½" from the base. Next a 15" and 16" length are cut from the steel rod and, using a 3/32" drill bit, lateral holes are drilled at three ends of the rods with one end of the 16" rod undrilled since the pulley and washer will suffice to hold it in place. The drive and idler rods (16 and 15" rods) are slid through one set of eye-bolts and the rubber washers are slipped on. Cotter pins, washers and pulley are then fastened. When the motor is positioned, the tension in the V-belt should not be excessive since it will bend the eye-bolts out of line.

At this point, the tumbler is operable. Start the motor and place the tumbler drum on the "washers". If it does not rotate it will need a 1" strip of rubber around each end. It may be possible to cut a continuous band from a tire tube which can be slipped right on without gluing. Note that the smaller cans (4" dia) will rotate without any preparation. Note also, that the drums may wander off the rubber washers if the rods are not level. To remedy this, carriage bolts are positioned (Fig. 1 and 6) to restrain the drum from traversing off the rubber washers. If you intend to let the tumbler run unattended, these are a must since the drum may otherwise slip off one runner causing the other washer to wear down considerably while in contact with the stationary drum.

DIAGRAMS

Scale of diagrams:
Fig. 1......... 2:9
Fig. 2......... 2:3
Fig. 3......... 1:1
Fig. 4......... none
Fig. 5......... 1:8
Fig. 6......... 2:3
Fig. 7......... none

Fig. 1
Completed Tumbler



Rubber Washer

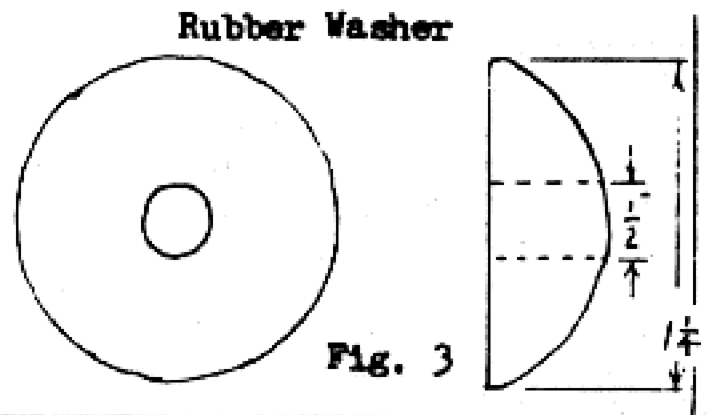
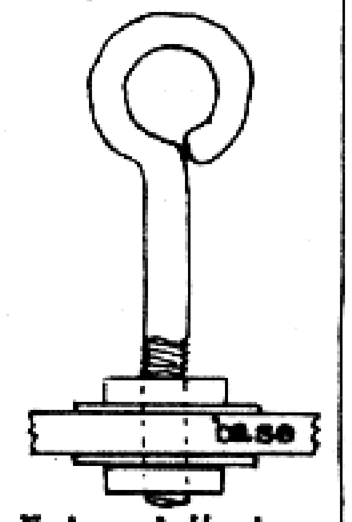


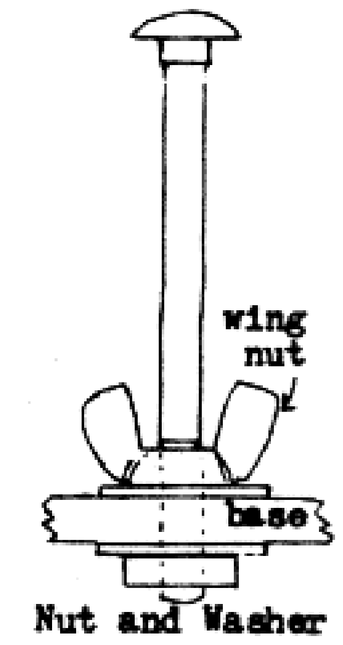
Fig. 3

Fig. 2
Eye-bolt

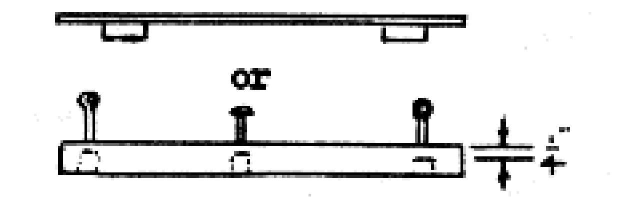


Nut and Washer positions

Fig. 6
Carriage Bolt



Nut and Washer positions



Types of Bases Fig. 4

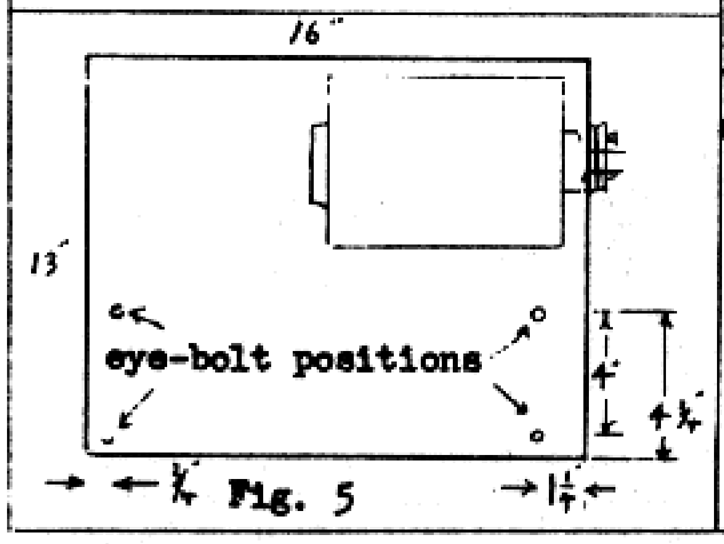


Fig. 5

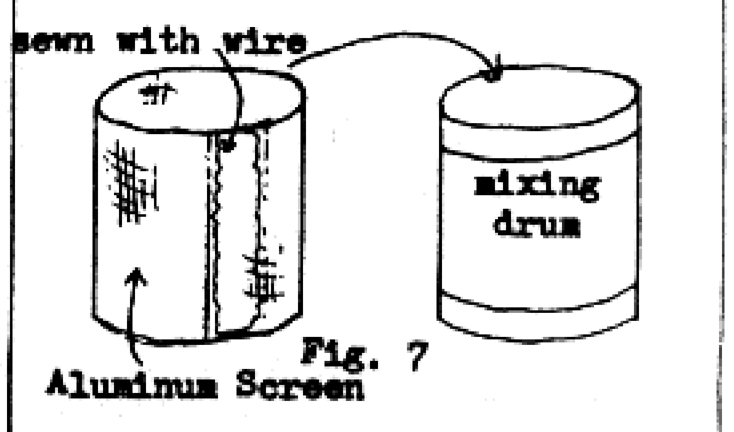


Fig. 7

The Mixing Drum: This author has found that a large dry-food-container can with a replaceable plastic lid (potato sticks, coffee, etc.) will work quite satisfactorily and that the smaller cans are convenient for smaller loads and don't need any preparation. If at all possible however, an aluminum or other non-rusting container should be obtained. Remember, the larger the can the less RPM will be produced causing less efficient tumbler action. This is not to say that high RPM will be more effective, but if the tumbler is set for a small can's ideal RPM, simply replacing this can with a larger one, without changing pulleys, cannot produce the desired results.

Be careful when using, if at all, containers which use screw-on covers. They present much more danger to the operator if a mixture ignites while inside such a can. Those with plastic lids are much more desirable although they may begin to leak minute amounts of powder when they wear out. This is remedied by taping up the seam during mixing.

About the Balls: In pulverizing, almost any kind of shatter-proof ball could be used. Some suggestions are: steel (most common type) aluminum, lead and even fishing sinkers are a possibility. A half inch diameter is a good size. However, never use a metallic ball or any hard ball with chemical mixtures. Both sparks and impact could set off the dust clouds that form inside the tumbler. Specifically for mixtures, I use either golf balls or nothing at all. However, in the commercial manufacture of black powder, wooden balls are sometimes used, so this is another posibility for those who have access to a wood lathe.

I've discovered one trick which allows for a slower drum RPM and increases pulverising power. That is to line your drum with an aluminum window screen of about 16 mesh (Fig. 7). It should be fitted to the can then taken out and "sewn" together with a piece of copper wire. Usually the chemicals will build up underneath the screen, so the pulverized chemical and screen should be taken out and the screen replaced in again.

Actual construction of this Chemical Tumbler by the reader will no doubt suggest additional refinements and improvements; I would welcome any comments or questions you might have.

40 Dale Ave. RD#1 Dracut, Mass. 01826

** ** ** **

(Ed. note: Our sincere thanks to Jim Buja for preparing the above article and diagrams in camera-ready form according to our instructions in a previous issue. (See April 1970 AP for this data and Jim's earlier article on constructing a "pyrotechnic paper cutter".) We have had a number of requests for information on construction of a ball-mill and are sure this article will answer many readers' questions. Samples the author has sent us of chemicals pulverized in his tumbler are of the finest grade and we are glad to pass the foregoing information along.

SPLICING PIPED MATCH

When preparing set pieces for a display, the most often-repeated operation is that of joining two pieces of piped match to convey fire from one to the other. Thus, it is one of the first skills the prospective fireworker should learn. Unfortunately, the literature has few if any exact descriptions of how this important operation should be done, and the beginner must first learn it on the job. It is hoped that the following instructions will help in preparing him to make fail-safe splices quickly and efficiently at his first display.

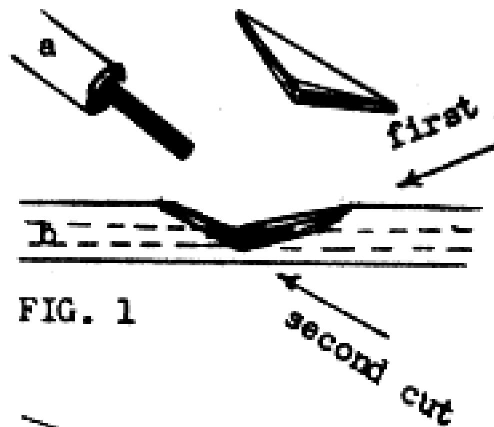


FIG. 1

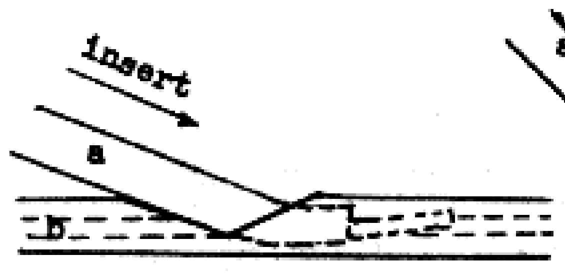


FIG. 2

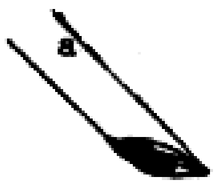


FIG. 3

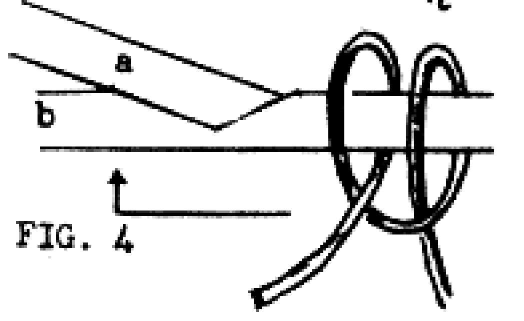


FIG. 4

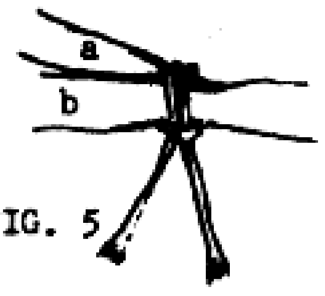


FIG. 5

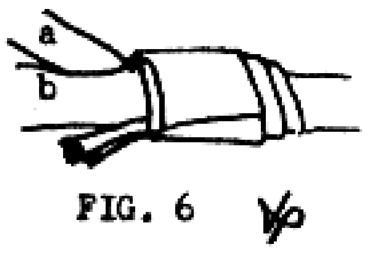


FIG. 6

Joining piped match, hereafter referred to under the more commonly-used term "match", divides into two categories: connecting two lengths end-to-end, or splicing a terminal end into another continuous length. The latter operation, known as "cutting-in", requires slightly more skill and will be described first. In the above illustrations, the piece marked "a" represents the loose end and "b" the length being spliced into.

FIG. 1 shows the first step; the paper pipe is trimmed back about ½ inch at the end of "a", leaving an intact piece of bare match protruding; then a wide-angled V-shaped cut is made in "b", being careful not to cut into the match itself. For these operations, a small pair of sharp scissors is used, a favorite among fireworkers being Wiss electrician's shears, model 175-E. These are only about 6 inches long and can be hung about waist-high on a piece of twine around the neck, leaving both hands free for other operations. The pipe marked "b" is grasped between thumb and forefinger of the left hand (if you are right-handed) and with scissors in the right, a cut is made downward as shown, just to but not into the match, whose position can be felt by the other hand; then the tip of the shears is slanted upward and the cut continued to remove a piece of the pipe about as illustrated and expose the match. With practice, making the cut becomes one smooth operation, with two snips of the shears.

The end "a" is then inserted into "b" as in FIG. 2, so that the two pieces of bare match are in contact, and a piece of twine is tied around the pipes just to the left of the notch to secure them, as in FIGS. 4 & 5, with the excess twine snipped off. Finally, about two inches of 3/4" masking tape is wrapped around the joint, FIG. 6.

The knot shown is the traditional fireworker's "Clove Hitch", probably favored because it can be tied rapidly and almost one-handedly in a single operation. For clarity, it is shown in FIG. 4 somewhat to the right of where it is actually tied, the correct position being illustrated in FIG. 5. Actually, a simple "overhand" knot would do the trick if secured by a second knot of the same type, but this would involve two tying operations with the risk of slippage between the first and second, as anyone knows who has used it for securing bundles.

It is suggested that the beginner consult FIG. 4 and practice tying the Clove Hitch, at first around a solid rod such as a pencil or dowel, until it becomes second nature. Its advantages will soon become obvious, and once he can do it effortlessly he will be recognized as a real fireworker. Tony Semenza does it almost faster than the eye can follow! No attempt has been made to describe the operation in words, since every operator will discover the way that works best for him, be he right- or left-handed.

The tying cord generally used by the pyrotechnist is a rough brown 3-ply flax of about the same thickness illustrated, known in the trade as "Italian Shell Twine". Because it is not smooth, knots made with it hold firmly, even when not pulled up so tightly as to "choke" the tubing. A satisfactory type is widely sold for tying packages.

In last month's AP we mentioned that two methods of "cutting-in" piped match were used at the San Diego stadium display. The one just described was used and advocated by Tony Semenza to insure absolute security of splices and positive fire-transfer. Chief pyrotechnician Ray Contrucci preferred a simpler and quicker method, understandable when some 460 such splices had to be made, and summed it up with the statemnt, "There's no way this won't work!"

With the simpler method, the end of the pipe to be inserted is not trimmed back from the match but merely cut off diagonally as in FIG. 3, leaving the match flush with the cut. It is then inserted into the notch in "b", pointed part upward, so that the match is in contact or nearly so with the continuous length running through "b". Quickmatch burns vigorously enough that there is actually little chance that the fire will fail to transfer from one piece to the other in a closed tube, even if slightly separated. Also, in this quicker method, the joint is not tied with twine but merely wrapped with a few turns of masking tape. In either case, the tape covers the gap between pipes, protecting the match from moisture and stray sparks, but in the latter, it is also depended upon to hold everything together. Perhaps the fairly recent availability of masking tape calls for an updating of traditional splicing methods!

In end-to-end joining of two lengths of match, each will usually have a piece of bare match extending from the pipe as in "a", FIG. 1, covered by a protective safety cap slid over it. The cap of one can be removed, cut to a desirable length, replaced and tied securely, while the other cap is discarded. The second length is then slid into the open end of the cap, bringing the ends of bare match together, and another tie made around this end.

These match-splicing operations are essential not only for interconnecting lancework frames but in preparing other sets and fireworks like wheels, "trees", and finale batteries, and they should be learned early in the game.

ROCKET MOTORS BASED ON MALEIC HYDRAZIDE

by Fred Wagner*

In the April 1970 issue, our Chief Green Man enlightened us with his article titled "Basic Skyrocket Construction". In the following article I will give exact details for successful construction of a rocket charge using a propellant to which I have patent rights pending.

A typical casing size is 5 inches long with ½-inch bore. The clay I have used with most success is that used in Estes Model Rocket Engines as nozzles; I get the clay from the engines after they have been fired.

There are only two ingredients in the propellant: potassium perchlorate and maleic hydrazide. If you have trouble obtaining maleic hydrazide in your area, it can be obtained from: Distillation Products, Eastman Organic Chemical Dept., Rochester, N.Y. 14603.

Two parts of potassium perchlorate and one part of maleic hydrazide, by volume, are finely powdered, then well mixed to obtain a homogeneous mixture. NOTE: this mixture is hygroscopic (absorbs moisture from the atmosphere) and should not be mixed when the humidity is above 70% or there will be a reduction in rocket performance.

Otherwise, the combination is very stable and will not explode or ignite during mixing or ramming. I have loaded about 25 motors with no difficulty, but only after subjecting small amounts to very heavy impact and friction testing.

In making the motor, it is advisable to coat the spindle lightly with candle-wax to facilitate removal from the spindle after ramming. The casing is then placed on the spindle and, using a paper funnel, ½ teaspoonful of clay is poured into the top. Push the rammer with the longest hole down over the spindle and hit it 15 times with a rawhide mallet (refer to the article noted in first paragraph). This forms the nozzle.

Next, the propellant charge is added in ¼-teaspoonful amounts, ramming each with twelve hard one-foot hits of the rawhide mallet and changing drifts as the charge mounts in the casing, until about one ounce of propellant has been loaded. Several ¼-teaspoonful scoops of meal powder can then be rammed on top in the same manner, finishing with another ½-teaspoonful of Estes nozzle clay, rammed either solid or with a piercing drift if a payload is to be carried.

After twisting the charged casing slowly off the spindle, the end of a 5-inch piece of safety fuse is kinked slightly and inserted into the central cavity for ignition. A stick can be attached and a paper cone with or without a charge of stars and blowing powder, or the motor can be inserted into a regular rocket vehicle. I personally do it the Estes way, placing a piece of safety fuse in contact with the meal powder and ramming the clay around it. This acts as a delay before igniting some grained black powder to eject a parachute for safe recovery of the rocket. Thus, the motor described can be adapted to either a regular rocket vehicle or a skyrocket complete with stars or a salute. In the latter case, it may be launched from a pipe, or, as a rocket vehicle, from a rail; I have used both methods myself.

This, then, is how to make rocket motors using potassium perchlorate and maleic hydrazide. Have fun with them!

BASIC SKYROCKET CONSTRUCTION

by M. P. Vander Horck

Rockets are among the oldest pyrotechnic devices known, probably antedating even the rudimentary firecracker. There is little doubt that the first rockets resulted from four successive discoveries:

1) that a mixture of saltpeter and charcoal when ignited would burn without access to atmospheric oxygen;

2) that this mixture would burn more fiercely when confined in a bamboo stalk or other container than in the open;

3) that the jet of flame and gases issuing from the container would be longer and more forceful if the opening were "choked" or restricted in size; and finally

4) that by ramming the mixture solidly in a tube, with the addition of a little sulfur, and forming a hollow central cavity through most of the charge, the impulse of the exhaust gases could be made to propel the case for some distance.

Of these discoveries, the first three might well have been stumbled upon accidentally, but the last must have required a definite effort of some early pyrotechnist's imagination. The principle involved is, that the more surface area of powder exposed to the first flame, the greater will be the initial thrust. A little calculation will show that a cavity about 1/3 the diameter of the charge and extending about 7 times its diameter into the powder (a typical figure) will increase this surface area by at least 7 times over that of an "end-burning" solid charge. This principle was described in John Bates' "The Mysteries of Nature and Art", second book, written in 1634 but was certainly discovered long before.

The applications which have been made of the rocket principle for missile propulsion, signalling and illuminating devices, jet-assisted-take-off for aircraft, life-saving line carriers for ship-to-shore and ship-to-ship use, high-altitude telemetry and sounding, weather modification (as in cloud-seeding to combat hailstorms) and even as boosters in connection with today's huge liquid-propellant space vehicles, are too well known to require elaboration. We are concerned in this article only with solid-propellant rockets and specifically with those used for pyrotechnic display, generally called skyrockets.

(It should be noted that this category does not include so-called amateur or model rocketry, from which it differs in several important respects. Amateur rocketry generally makes use of solid end-burning charges of comparatively slow-burning propellants such as a sulfur and zinc dust mixture, either poured into the casing in a molten state and allowed to solidify or moulded or machined to fit. The case itself may be of metal (never used in skyrockets) and reusable after recovery, and the exhaust nozzle must be carefully formed to take maximum advantage of the available thrust, which does not reach a peak until the rocket is well on its way. This nozzle is closed by a brittle plastic or metal disc incorporating an electrical ignitor, which ruptures when enough heat and pressure have built up to sustain burning. A skyrocket, on the other hand, develops maximum thrust within about the first second after ignition and thereafter travels mostly on momentum, with the remaining powder contributing mainly to the brilliant "tail", which is noticeably lacking in amateur rockets.)

Solid-propellant rockets of all types have the disadvantage that they are "one-shot" devices and can not be turned on and off at will like those with liquid propellants, but this lack is compensated for by the fact that they can be stored indefinitely, ready for instant use. Moreover, they bypass the failure-prone valves and other sophisticated mechanics that have plagued space technicians in the building of missiles and space vehicles. (In the unlikely event that the reader does not know it, rockets are even more efficient in the vacuum of outer space than at sea level, since they do not depend on the pressure exerted by the exhaust gases on the atmosphere nor on atmospheric oxygen for combustion.)

For the pyrotechnist, two big advantages of the rocket over the aerial shell are that it does not require a mortar for firing, only a suitable above-ground launcher, and that there is not the abrupt set-back or shock like that delivered by the lift charge below a shell. Again, there is a disadvantage, that of the falling case and stick which today precludes the firing of rockets in public exhibitions except over large clear areas or bodies of water. Where the latter conditions prevail, however, it should be remembered that the comparatively mild acceleration of a rocket permits the use of chlorate stars which would be too sensitive for the conventional aerial shell. (Note that the name "stickless rocket" is sometimes applied to comet shells which leave a brilliant trail as they ascend, but these require a mortar and lift-charge for firing.)

Skyrockets today come in many sizes. While Brock, in his "History of Fireworks", has mentioned eight-foot-long monsters with sticks of 20-foot length or so, the largest that are likely to be encountered, even in exhibition work, would not exceed about two feet in length or three inches in diameter. The great majority are under the "one-pound" maximum (8" long) and range from the very small "bottle rockets", so called because they are essentially nothing but open-ended 1½" black powder firecrackers and can be launched from the neck of a pop-bottle, to those about six inches long, complete with a nose-cone filled with stars which bursts at the top of its trajectory. Some of the smaller rockets have no such "garniture" and are called "honorary" rockets, deriving their whole effect from the glowing tail and the "whoosh" as they go up. The propellant is always a mixture of saltpeter, charcoal and sulfur in varying proportions, with more charcoal used in the larger sizes as noted below. Usually, bigger grains of charcoal are included than actually neccessary for combustion, to enhance the effect of the glowing tail. Metallic inclusions like steel or iron filings, titanium, etc., can also be used to increase brilliance but should be kept to a minimum since they add to the weight of the rocket without contributing to thrust. (Iron or steel particles should of course be treated to prevent rusting by the saltpeter.)

For dimensional and construction details in this article, we have chosen a typical "one-pound" rocket, but note that the proportions given for length, diameter, etc. can be equally well applied to larger or smaller rockets. For example, the ¼" nozzle for a 3/4" bore can be reduced to 1/8" for a 3/8" bore, with other measurements reduced accordingly, as noted in the instructions for a "sub-ouncer" rocket described at the end of the article. The only proportion which varies from small to large rockets is that of the charcoal to the other ingredients.

ONE-POUND SKYROCKET AND RAMMING TOOLS

(half actual size)

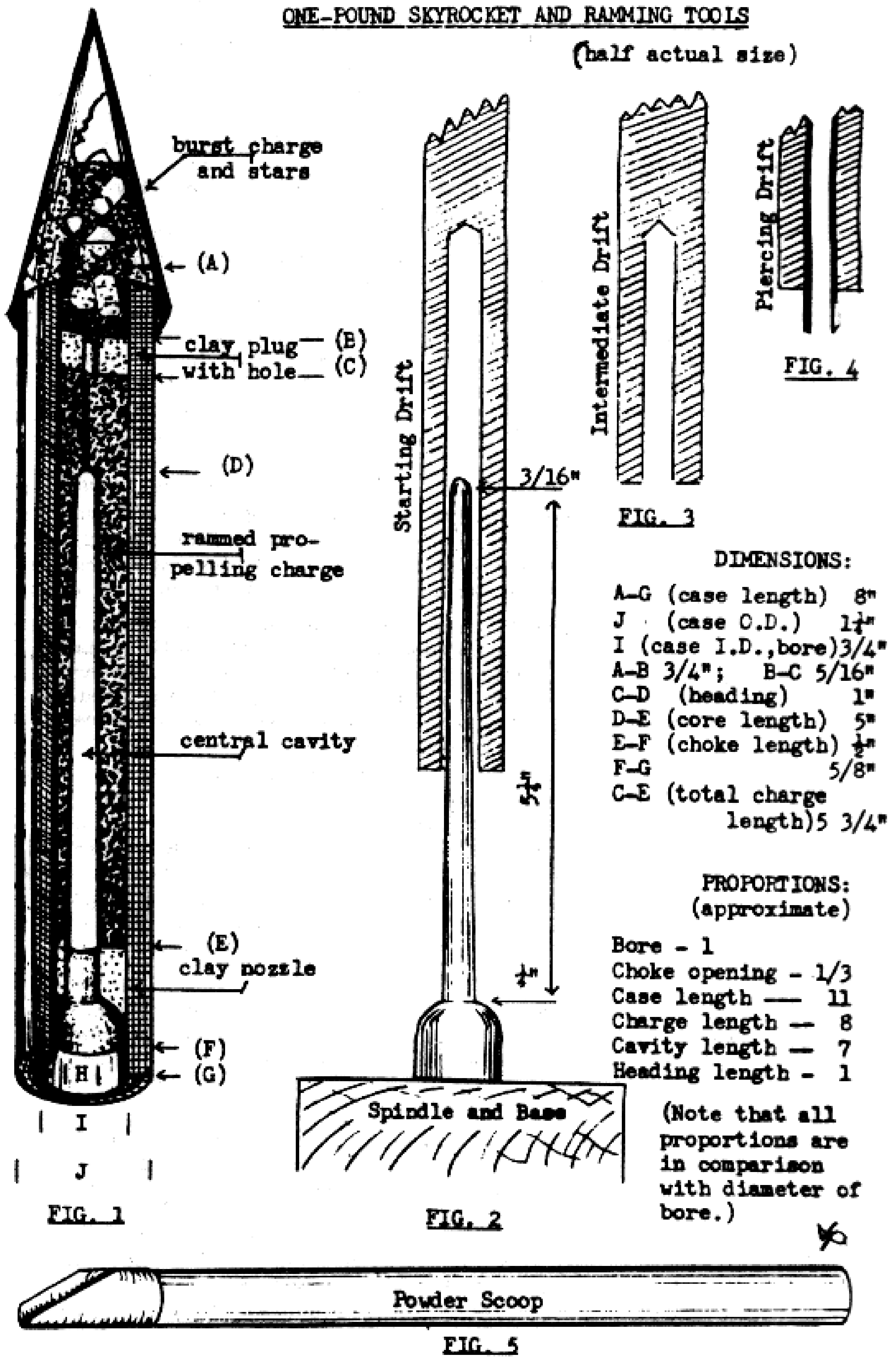


FIG. 1

FIG. 2

FIG. 3

FIG. 4

FIG. 5

DIMENSIONS:

A–G (case length) 8"
J (case O.D.) 1¼"
I (case I.D., bore) 3/4"
A–B 3/4"; B–C 5/16"
C–D (heading) 1"
D–E (core length) 5"
E–F (choke length) ½"
F–G 5/8"
C–E (total charge length) 5 3/4"

PROPORTIONS: (approximate)

Bore - 1
Choke opening - 1/3
Case length — 11
Charge length — 8
Cavity length — 7
Heading length - 1

(Note that all proportions are in comparison with diameter of bore.)

TOOLS: Fig. 1 is a cutaway view of a typical "one-pound" skyrocket, with the hollow core left unshaded for clarity. As with certain other fireworks nomenclature, the term "one-pound" is deceptive, since it is derived from the weight of a lead ball of the same diameter as the outside of the casing; the rocket actually weighs less than a half-pound when completed. The casing is rolled around a 3/4" metal or wooden former, beginning with an 8" by 17" strip of hardware paper and finishing with an 8" by 20" piece of 120# chipboard inserted into the last turn of hardware paper, both pieces well pasted. When dried, this results in a very sturdy tube with a smooth bore. But case rolling is an art in itself, too elaborate to cover here and modern mass-production has made it almost unneccesary for the pyrotechnist to "roll his own" except as a pastime on rainy days!

The same does not apply to rocket loading tools, however, and the pyrotechnist with some machining ability and access to a lathe can profit by making his own tools. These are illustrated in figures 2 through 5. It is essential that the spindle and drifts be made from non-sparking materials such as brass or alumimm, since the greatest danger in ramming black powder is from accidentally striking a spark. In factory work, the spindle itself is often of steel or gunmetal for durability and long wear, but this demands that the drifts be made of non-ferrous materials. This writer prefers brass for both spindle and drifts, although aluminum is cheaper, easier to machine and quite satisfactory unless large-scale manufacture is planned. The spindle in particular should be highly polished to facilitate ease of removal after the charge is rammed.

The starting drift is the most difficult to make (Fig. 2) because the central hole which fits over the spindle is comparatively long and must be bored exactly parallel to the outside for its entire length. This fact almost demands the use of a lathe, or at the least a drill-press. The hole must be just large enough to fit over the spindle at the base (in our example, ¼"). We have shown only one intermediate drift, but two or more are generally used, with progressively shorter holes to match the rising charge of composition and fractionally smaller diameters to correspond with the taper of the spindle. These drifts can be made of hardwood dowel material if desired, of the same diameter as the former on which the case is rolled, but the top should be wound with wire or have a tight-fitting metal sleeve to prevent spreading and cracking from repeated mallet blows. If of larger diameter than the drift itself, such a sleeve will present a better surface for the mallet to strike and facilitate removal from the case. A finishing drift (not illustrated) with no central hole is used to ram the "heading" above the top of the spindle and the top clay plug, if the latter is to be solid. Some operators prefer to do this and afterward drill a small hole to communicate fire to the "pot" to ignite the burst charge. A quicker method is to use a "piercing drift" to ram the clay and form the hole in the same operation (Fig. 4). This can either have a projecting pin about 3/16" in diameter or a tube of thin brass or aluminum running through the drift as shown. We prefer the latter because it actually removes the clay and does not press it down into the powder, and it easy to clean out if it becomes plugged. Moreover, the operator can judge by examining the removed clay whether the hole extends just through the plug and into the composition (as it should) or is too short or long and adjust the length of the little tube accordingly. Starting with a tube press-fit into the drift and flush with the top, extending about 5/8" out the bottom, the operator can cut or file it to the correct length. Just a little black powder showing in the end of the tube after ramming the clay indicates that a hole of the right length has been made.

Fig. 5 shows a simple powder scoop that this author has found very convenient to introduce the composition into the casing with minimum spillage. It is made of a length of dowel about the same diameter as the bore or slightly smaller, with a piece of tubing fitting tightly on the end and shaped about as shown. By inserting it into the case and tapping it lightly, all the powder will fall into the tube.

A fairly heavy rawhide mallet is used to ram the composition, mainly because a solid metal hammer would soon deform the top of the drifts. (Note: a rubber mallet is completely unsatisfactory; it does not deliver enough impact to consolidate the clay or powder properly.) The spindle itself should of course be installed on a substantial base, such as a block of hardwood; this can be done by drilling and tapping the underside of the metal shoulder and running a 5/16" or 3/8" bolt up through the wooden base, after recessing the bottom to accept the head of the bolt.

The only other tool needed (optional) is a conical form around which to shape the paper nose. It should be tapered about as shown in Fig. 1. A disc of about 6" diameter is slit radially out from the center, wrapped around the former with the bottom edges even, and pasted where it overlaps.

CLAY: Either fireclay or what is known in the ceramic industry as "grog" or "grout" can be used (the former obtainable at brickyards and the latter at ceramic shops). This is used in its powdered form, which usually has enough residual moisture to compact firmly when rammed, though it feels dry to the touch. Its suitability can be tested by removing the case from the spindle after forming the choke and examining it. The rammed clay should be smooth and hard to the touch, though grooves can be scratched in the surface by a sharp instrument. If it has a tendency to crumble, it may be slightly dampened, preferably with oil. Water, especially in excess, may cause shrinkage as it evaporates.

PROPELLANT: For a one-pound rocket, Weingart has recommended a mixture of 16 parts saltpeter, 12 charcoal, and 3 sulfur (by weight), while Brock has specified 13, 7¼ and 2 respectively. It can be seen that the two writers differ mainly in the proportion of charcoal to be used, but that in both cases this is much larger than that of strong black powder (15, 3, 2). Lancaster, in the formula he has supplied for Ellern's "Military and Civilian Pyrotechnics", recommends proportions that work out to 15½, 8, 1½, which is pretty close to Brock's, no doubt indicating British preference, but he does not specify which caliber rocket this applies to.

Since every pyrotechnist seems to have his own pet formula, this writer might as well recommend his own too, which is 14 saltpeter, 8 charcoal and 2 sulfur, and refer the reader to Weingart's sage if simplistic advice: "If rockets burst before ascending add more coal; if they ascend too slowly add more saltpeter." In general, however, the larger the rocket, the more charcoal should be used, and for a spectacular tail, it should be about a half-and-half mixture of fine and coarse. For smaller than one-pound rockets, the saltpeter should be powdered; for larger ones, the granulated grade may be used.

RAMMING: The case is slipped over the shoulder of the spindle, where it should fit snugly, and a scoop of clay is dumped in and the starting drift pushed down over it and given eight to ten hard blows with the mallet to form the choke. The drift is then removed and a scoop of powder added, which is consolidated by replacing the drift and giving it about half-a-dozen somewhat lighter blows. However, do not be too gentle, as the proper performance of the rocket will depend on firm packing of the composition. This process is repeated till the case is full to about an inch from the top, changing to the shorter intermediate drift(s) at the proper time, and using the solid finishing drift for all powder above the spindle top. (Two marks on each drift to show its lower and upper limit are helpful; if the second drift is used too early, it may scratch or deform the spindle.)

Finally, another scoop of clay is put in and consolidated with either the finishing or piercing drift, as desired. As an added touch, the fire-hole can receive a daub of priming-paste to insure ignition of the burst-charge (black powder with 2% dextrin or starch and moistened with water).

FINISHING: The nose-cone is inverted and about half-filled with stars and a burst-charge of about FFFg or FFFFg grain or strong meal powder; adhesive is applied around the rim of the rocket, which is pressed down into the cone and again turned right-side-up to dry. Be sure the cone is properly aligned. (If fancy paper is to be wrapped around the case, it should be pasted on before attaching the cone, with about two inches extending beyond the choke end.) About six inches of black match or (preferably) 1/8" safety fuse is inserted into the nozzle, with a good four inches extending, and attached with another daub of priming paste, which should completely fill the hole in the choke. When this sets, the extending paper can be twisted around the fuse and tucked in. The stick is then smeared with glue on one side for about six inches and securely bound to the case with twisted wire about an inch-and-a-half from each end. A stick for this size rocket should be roughly ¼" thick and three feet long. Be sure it is parallel with the case before the glue dries.

COMMENTS: As stated, the foregoing description applies to a basic "one-pound" commercial skyrocket, made by hand. In practice, they are often, if not usually, made by the use of hydraulic gang-rammers, on the same machines used for roman candles. The writer has seen such a machine capable of ramming 144 cases at the same time, but the same steps described are followed for each operation, only with more than one casing. "Shifting boards" are used in place of powder scoops to dump exactly equal amounts of clay and composition into all tubes at once, and all rammers (drifts) go down to the same depth and at the same pressure, achieving great uniformity of compaction, which says something for mechanization in fireworks manufacture!

One writer has asked us why, if rocket casings are loaded with black powder, they don't explode like a firecracker. The answer is, that by virtue of being tightly packed, the powder burns only on its surface. To "explode", black powder must have a little "breathing space"; if about half the powder in a rocket were placed loosely in the casing, it would undoubtedly blow up, if the quality of the powder were good. When this happens, it is a sure sign that the ramming has not been done correctly, leaving air pockets within the charge or around it, or that the powder is too strong.

Another frequently-recurring question is, why doesn't the powder crumble and fall away from the sides of the case after it is removed from the spindle, if no binder is used? The simple fact is, that it doesn't if firmly compacted. There is enough adhesion between the particles so that the rammed charge remains solid, even under comparatively rough handling, as experience will demonstrate.

"SUB-OUNCER" ROCKETS: Newcomers to the pyrotechnic field may wish to learn first-hand the principles of rocket construction without investing in tools for the one-pound size or mixing large batches of powder. In the January 1967 issue of "PYRONEWS" (the second issue of the now defunct publication which preceded AMERICAN PYROTECHNIST), this editor presented an article on making three-inch rockets with very cheap tools and materials, based on suggestions by W.R. Withrow. Though these little rockets weigh only about a third of an ounce, they perform remarkably, reaching heights of 500 feet or so, and can even carry a few small stars.

The materials required are only a couple of feet of 3/8" dowel, a roll of 3" gummed paper tape, a nailabout 1/8" in diameter and 2½" long, a piece of board for the base of the spindle and a suitable stick such as 1/8" dowel about two feet long. Construction of the spindle and drifts will be obvious from Fig. 6 below:

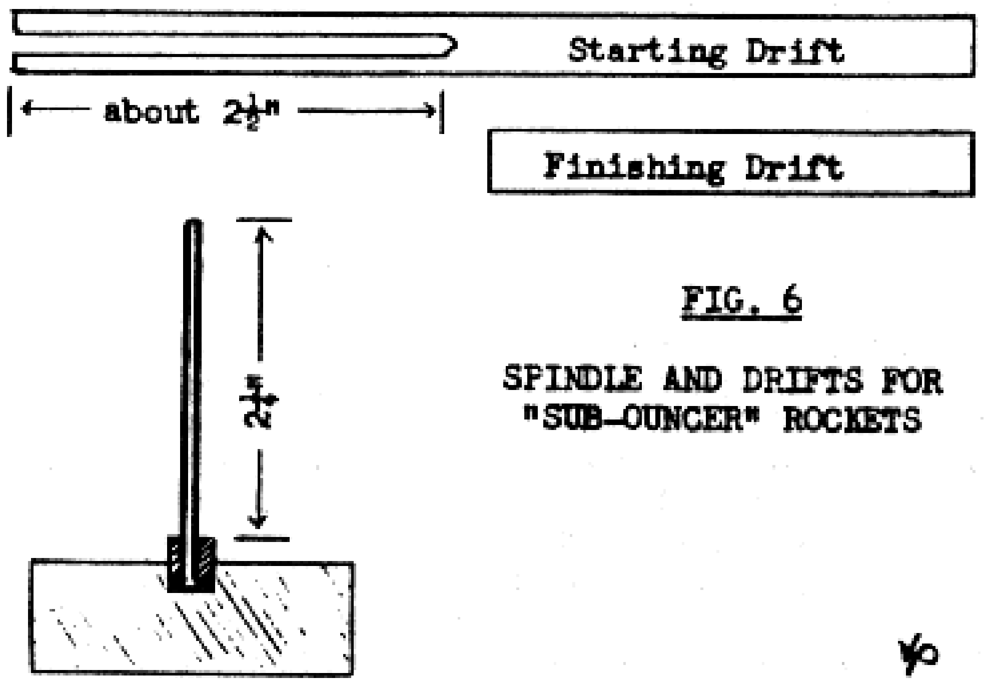


FIG. 6

SPINDLE AND DRIFTS FOR "SUB-OUNCER" ROCKETS

Cut off a ½" length of dowel and drill a hole lengthwise for a press-fit over the nail; then bore a 3/8" hole ¼" into the board to be used as a base, and, pushing the nail into the piece of dowel up to the head, glue the piece into the base as shown. File off the point of the nail into a rounded end and be sure the length of it is perfectly smooth. The two drifts are cut from the dowel to any convenient length that will extend above the 3" case when inserted, and a 1/8" hole bored in one of them as shown. This illustrates the fact that a rocket spindle need not neccesarily be tapered, and, if it is perfectly cylindrical, only one drift is needed until the charge reaches above the top of it. The main reason for the taper in larger spindles is to facilitate removal of the charged case after ramming.

The case is made from a 10" length of the 3" gummed tape rolled around another length of dowel. This is best done by first rolling up the entire length, keeping the ends even, then unrolling all but about the last turn-and-a-half, wetting the remaining length with a wet sponge or cloth, and re-rolling it tightly, again keeping the ends even. Making up a number of such cases is good practice, and when they are dry, they are ready for loading. It is well to rub the former with paraffin occasionally to prevent sticking, and sometimes a slight backward twist must be given it to remove it from the rolled casing.

Loading and ramming proceeds exactly as previously described for one-pound rockets, except that only the starting and finishing drifts are used. If it is desired to add a garniture of stars, a piercing drift may be used in ramming the top clay plug, with a sharpened length of 1/8" nail in the bottom, or the hole may be drilled afterward. In either case, be sure the hole extends just into the powder, or it may come too close to the central cavity and blow through prematurely. In place of a nose-cone, which is impractical in this small a rocket, another short length of gummed tape may be glued around the case with about half its width extending beyond the case. After the "pot" is placed in the tube thus formed, the upper end is glued or taped shut.

Small experimental rockets like the "sub-ouncer" are excellent for learning the rocket principle and are adaptable to other uses such as making "line rockets", which run along a stretched wire, or for attaching to revolving wheels as turning cases, or even as small fountains or "gerbes". In the latter two instances, however, it may be well to sacrifice some of the thrust produced by the hollow core in favor of longer burning-time. This is done by shortening the spindle to half its length, or even less and ramming the space above it solid. Once the technique of making these small rockets is mastered, all sorts of modifications will suggest themselves. As with all skyrockets, "the sky is the limit!"

In conclusion, and to forestall possible questions, there are two techniques in rocket construction which have not been mentioned here. One is that of ramming the case solid, afterward boring out the central core, and the other is formation of the choke by twisting a cord around the case to make a restriction or "waist" while it is still damp (a clay choke may may also be formed inside it in larger rockets). Neither technique is used much anymore in this country (but see page 9, July 1969 issue). It should also be mentioned that our British confreres employ the term "choke" to mean such a waist formed in the case itself, while in this article we have used it to mean any restriction in the open end, clay or otherwise.

(While much of the information in this rather lengthy article may seem rudimentary to the more experienced and advanced pyrotechnists among our readers, the author asks them to remember that all are not in the same class, and that they themselves probably asked many of the questions answered here — we certainly did! And then, we are often surprised to receive a letter saying, "Even as a fireworks man myself, I have learned things from your publication that I never knew before!", or words to that effect. So, in view of the inquiries we have gotten on the "rudiments" of fireworks manufacture, we don't feel that we have wasted space by trying to answer most of them in this issue, at least on the subject of skyrockets. In fact, the writing of it and the number of times we had to refer to texts made us realize how many of the "rudiments" we had forgotten, so if it was a good "refresher course" for this writer, we hope it may serve the same purpose in other quarters!)

Fire Away!

"Your excellent article on rocket manufacture has prompted a few thoughts about the commercial problems, and a few comments about these may help the beginner to avoid some of the more obvious pitfalls.

"Naturally, the critical factors are: (1)the area of the burning surface; (2) the diameter of the vent; and (3) the burning speed of the composition. The plain truth is that these are so closely related that every manufacturer has to adjust them to suit his own requirements and also to insure that he can constantly reproduce the same result.

"Once that (1) and (2) are fixed by the tools, the maximum variation will occur in (3), but it is essential that any variation is deliberate on the part of the manufacturer. The ingredients will be considered one by one.

"Potassium nitrate: This material must be the finely-ground variety passing 150 mesh and containing no crystalline material. Coarse particles will slow down the speed or make it erratic. The percentage used should be about 60.

"Sulphur needs also to be the finely-ground rock sulphur. Flowers of sulphur (sublimed) can be used, but it is less dense and compositions made with one variety should not be used with the other, lest the burning speed should change. The percentage should be 5 to 10. The writer favors 5%, but many use more and theoretically, larger percentages should consolidate better.

"Charcoal is the real trouble maker. The quality varies with the ash content, naturally, and an attempt should be made to get a good quality charcoal with an ash content of no more than 5%. The second factor is the moisture content. In practice it is difficult to deal with, particularly in the British climate, but the charcoal should be dried and always kept in a warm dry place. As one would expect, the influx of moisture and the consequent evaporation from the finished product will cause a breakdown of the burning surface.

"Some prefer to use fine charcoal which will pass 150 mesh, but there are two disadvantages; first, the composition becomes so light and fine that it does not consolidate; second, it burns so completely that the 'tail' of the rocket is poor. The best method is to use a proportional mixture of 3 parts 150 mesh to 2 parts 40/100 mesh, this mixture constituting 30% to 35% of the total composition in the rocket. Such a mixture consolidates well and produces a good tail.

"The picture which now emerges for a rocket of 3/4" bore is as follows: spindle base 3/8" tapering to 3/16" and 4 3/8" or 4½" long. The composition:

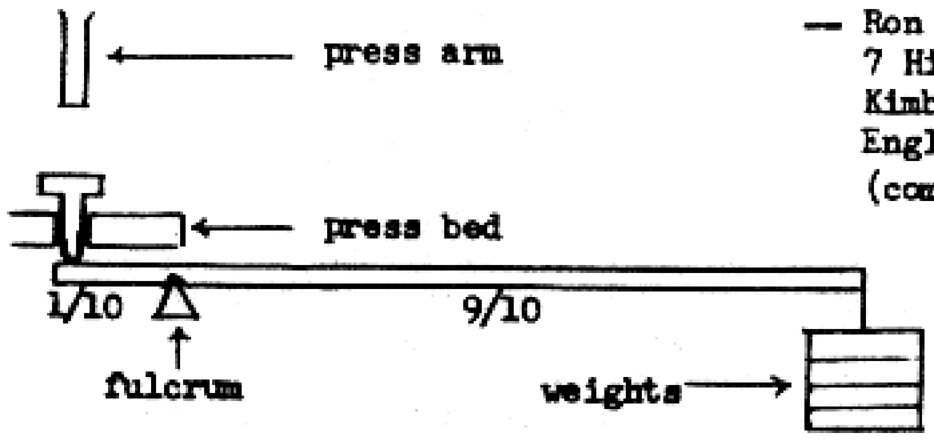
Potassium nitr.	Sulphur	Charcoal, 150	- 40/100
60	5	25	15

As you said, Van, if there are troubles, increase the speed by increasing the potassium nitrate and reducing the charcoal or vice-versa.

The 3/4" bore rocket is filled in about 10 increments, each of which must be equal; i.e., the scoop is overfilled and the excess scraped off with some safe object. Each scoopful must also be consolidated with the same pressure and the same number of blows or else the rocket may explode on firing.

"Hydraulic pressing is rather complex and expensive for amateurs, but a safe, reliable and cheaper method is to use a 'dead load' press. Arbor and mandril presses are easily available, the most useful ones having about 20" of 'daylight' between the press arm and bed. The base of the press is fitted with a weighted lever which gives a calculated resistance. When the weight is lifted, a known dead load has been exerted on the composition; for example, if the fulcrum is 1/10 away from the press bed along the horizontal arm, the pressure will be 10 times the weight of the load, which can be varied. The force exerted by the press is therefore equivalent to many blows with a mallet and is safer, quicker and more reliable."

— Ron Lancaster
7 High Street
Kimbolton, Huntingdonshire,
England
(communication from Malta)



"I enjoyed the article on rocket construction, but I've found in actual practice that a choke smaller in ½" was too small and blew out quite a bit of clay. Despite what Weingart and Lancaster say, actual measurement of present-day commercial American rockets shows choke diameters of approximately ½" I.D. Of course, every pyrotechnist has his own methods and materials and, as you say, the measurements are approximate and must be adapted to each person's techniques, raw materials, etc.

"You're right about iron or steel filings just adding weight without contributing to thrust. However, this is not the case with titanium, which actually increases thrust quite a bit and gives a tremendously bright silver tail. Rockets that start with the regular gold trail, then change to titanium are very effective, as are those using titanium throughout.

"WesTech now has available a TR on uses of titanium in many, many fireworks items, including rockets, as well as a complete line of 'Dura-Press' Kraft paper tubes that are ideal for rockets. Details on these and our complete line of rocket tools are available on request with a stamped, self-addressed envelope." — Ralph Degn (see page 6)

(Comment: we begin to think that Brother Ralph has a hang-up about titanium but are always happy to receive and relay the latest findings from one who has done more than anyone we know to pioneer its use in this country! — Ed.)

THE VERSATILE CONE

by Mike Gage

Paper-folding is an interesting and subtle art worthy of the attention given to it by creative talents around the world. But when combined with the exciting art of pyrotechny it becomes even more fascinating. For not only do you create an intricate structure, you provide it with a fiery life-force as well.

The paper cone, based on the geometry of the equilateral triangle, can be adapted to the making of fireworks in a number of interesting ways, such as skyrocket caps, mortar-shell powder cones, and most uniquely, the triangle firecracker. This cone is air-tight, light in weight, and holds together nicely, even without being glued. The size used in the following instructions was chosen at random; after you have learned the basic trick of folding, you can make whatever size you desire. (Large versions of this cone make good party hats, megaphones, etc.)

THE TWO BASIC FOLDS:

From a sheet of heavy typing paper cut a strip 2" wide and 7" long. Lay this flat on the table and fold one end toward you and across the strip as shown in FIG. 2. The trick here is to make this first fold so that it forms a 60° angle with the bottom edge of the strip and the outline ABC is a perfect equilateral triangle. (As a guide, you may mark a point "B", 3 7/16" from the right end of the strip at the top, and another at "A", 2¼" from the bottom right, joining them with a line as in FIG. 1 and folding on this line. Note that, whatever size strip is used, the length from "C" to the right edge is about equal to the strip width plus 1/8 this width, and for "B", 1½ times this figure - Ed.)

For the second fold, continue with the strip down under the bottom edge along the line AC and up against the back. The edge marked "X" in FIG. 2 should now lie directly along and under the first fold, BC, with the original lower right corner of the strip just reaching point B and forming a perfect equilateral triangle of 3 thicknesses (see FIG. 3). This is essential to the symmetry of the remaining folds, which are not illustrated.

At this point, if an air-tight cone is desired, fold about ¼" at point "C" back and under before proceeding.

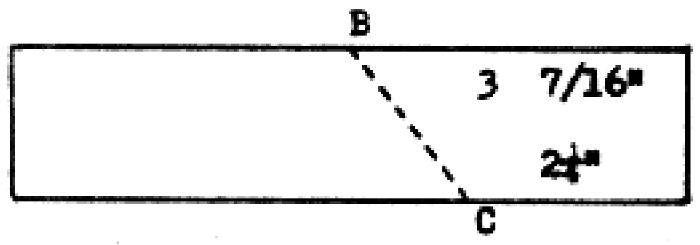


FIG. 1, 2 x 7 inch strip.

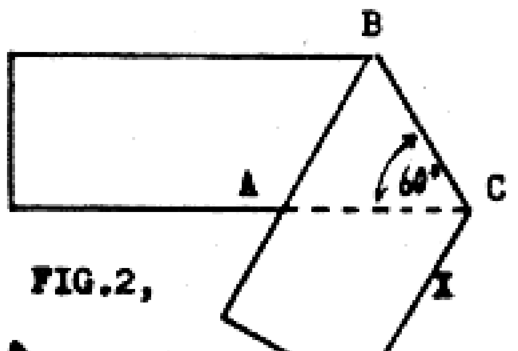


FIG.2,

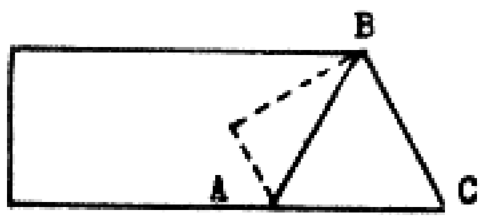


FIG. 3

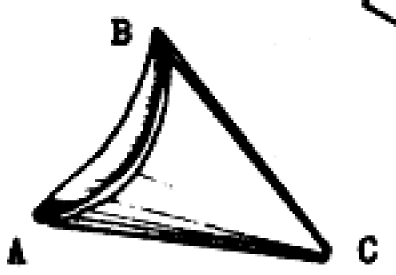


FIG. 4

Now fold the little tab shown by dashed lines in FIG. 3 down against the back of the triangle, along the edge AB, and fold the long strip down over it in the same way, so the longer edges of both will be under the edge BC and perfectly lined up with it.

Fold the strip up again toward the front along AC and finally the remaining flap to the back again over BC. This may either be tucked into the opening which it covers or pasted against the back to make a smooth case.

Round the cone out by pressing A and B together as in FIG. 4, and it is done. If you have made it air-tight by folding the corner C under after the first two folds, no air should leak when you apply breath pressure to the large opening.

* * * *

THE TRIANGLE CRACKER

Here again the versatile cone serves as the core of an interesting type of firecracker made in various countries of the Orient. It makes a whopping explosion from the mildest of compositions, yet is far safer than the cannon cracker, since it contains no end-plugs and is made with a soft case. You'll have fun with these. Here's how to make them:

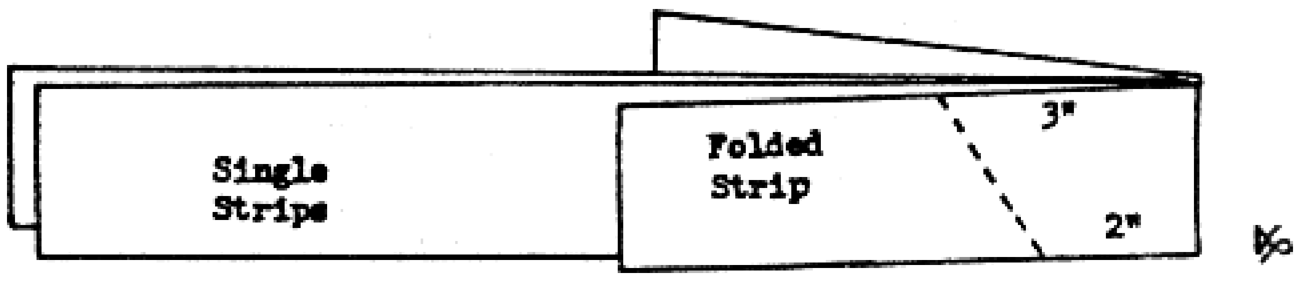


FIG. 5, 1 3/4 x 10 inch strips.

Cut four strips from heavy typing paper as before, but this time make them 1 3/4" wide and 10" long. Fold one in half and tuck two other strips into this fold, as in FIG. 5. With this 4-ply end form the two basic folds of the cone, as described above. (Again, a guide-line drawn as shown may help in making the first fold.)

The opening between the front 4 thicknesses of paper and the back 6 forms the powder pocket. Holding this so the remaining strips extend upward and to the left, press the sides together to bulge the cup out and put in about ½ teaspoon of powder, laying a length of safety fuse (at least 3") along the left-hand crease and pressing it down to the very bottom tip of the cone, as in FIG. 6.

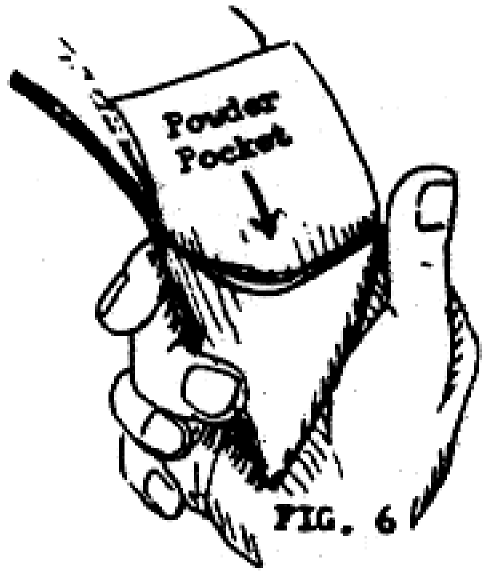


FIG. 6

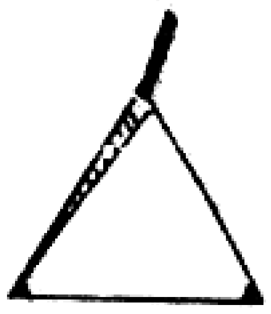


FIG. 7
Finished Cracker

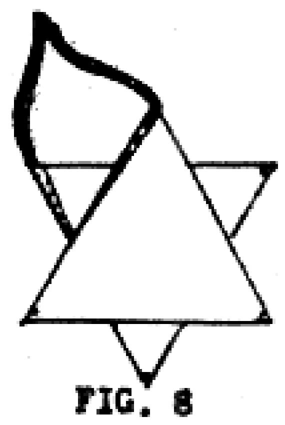
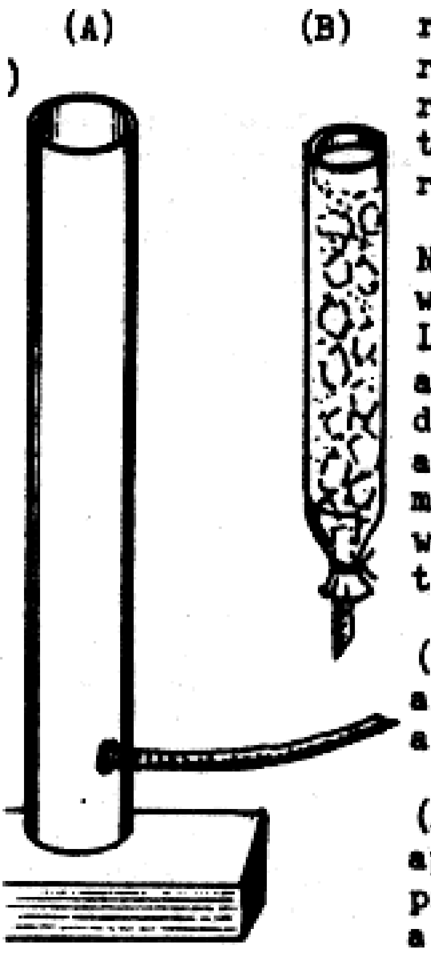


FIG. 8
"Texas Star"

More "Mini— Fireworks"



The March issue of AP carried a description by Peter Borger of his method of making very small rockets, which he called "Mini-Rocs". We have had reports that these were tried out by some of our readers with very satisfying results — although the cases were only about 1½ inches long, they did reach heights of 100 feet or so.

Now would you believe a miniature aerial shell? It was dreamed up by Russ Bettes, 207 Wabasso, Walled Lake, Mich. 48088, who had not seen the "Mini-Roc" article when he submitted his creation to us. The drawings at the left are approximately "life-size", and this is no April Fool joke. Russ thinks this may be the smallest mortar in the world, and we won't argue with him but just present his description without comment or recommendation.

(A) shows the mortar, wound on a 5/16" former and about 3" long, mounted on a suitable wooden base and fitted with a piece of 3/32" waterproof fuse.

(B) is the shell, made on a ¼" former and 1½" long, approximately, with the bottom crimped around a piece of the same fuse about ¼" long and held by a piece of twisted fine wire, as shown. It is filled with pebble-sized "stars" made by breaking up pumped or cut stars and a bursting charge of as much F-grain gunpowder as will fit in an empty .22 caliber shell. The open end is sealed with a mixture of water glass (aqueous solution of sodium silicate) and powdered chalk to make a thick adhesive.

The driving charge, consisting of twice as much F-grain powder as used in the shell, is poured into the "mortar" and the shell inserted on top of it — and there's your "Mini-mortar-and-shell". Russ says it gives "a very cute effect — a slight bang, followed by the shell arcing to a height of about 25 feet, then a midget, spreading burst."

It seems to us that this concept of miniature fireworks, with little inherent danger or noise as long as the composition is held to small amounts, may prove a good solution for the amateur whose experiments are limited by an unfavorable environment, like the Indian who "builds a small fire and sits close to it". Undoubtedly our readers will come up with more along this line of thought!

Lately I've noticed that the trend has been toward "Mini-Fireworks". How about a really teenie-weenie rocket made as follows:

Place a straight pin on either side of the head of a cardboard safety match. Then wrap it in a piece of aluminum foil about ½ inch wide and 3 inches long, making sure that the foil is tight and that there is no place for the exhaust to escape. Remove the pins and prop the rocket up either in some loose dirt or on a bent pin (a pipe-filter makes a good bazooka-type launcher and it can be hand-held). The rocket is lit by holding a lighted match under the head. Brett Howard, Orange, N.J. P.S. What is a "hammerhead", anyway?

(Works fine, Brett! About as "mini" as you can get with fireworks, but they seem to be strictly the daylight type — you can't see where they go after dark. But by crushing the grains from a charcoal-filter cigarette and wrapping them into the tinfoil around the match-head, the nighttime performance is improved. Takes longer to ignite and shortens the trajectory somewhat, but makes a nice spark trail. We also found no difference by eliminating the pins during the wrapping; the hot gases seem to form their own exhaust-vent.) A "hammerhead" is a loud salute, cylindrical in shape, with a side-fuse which makes it resemble the head and handle of a hammer. It is banned in most states.

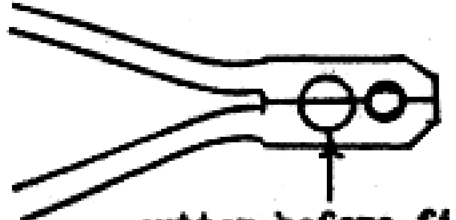
* * *

I thought you might make a short column similar to the American Radio Relay League's "HINTS AND KINKS"; in it you could include little things like the following:

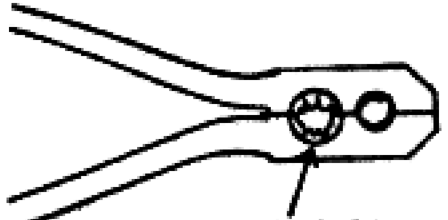
(1) You can make a very pretty star-shell easily by using the heads of ordinary paper matches as stars, firing it from a small mortar.

(2) The center rolls from adding machine paper are made of very strong cardboard and make excellent mortars when glued to a small block of wood. Some are as long as 7 inches or better and make good casings for many types of fireworks. Banks and Savings-and-Loan associations are good sources, as they use a great many of these machines.

(3) An inexpensive crimper for small diameter tubes can be made by filing the edges of the cutter in certain types of pliers as shown; then just insert the end of the tube and squeeze. P.J. Borger, Elmhurst, Ills.



cutter before filing



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(Looks as though you wrote the "HINTS AND KINKS" column for this issue, Pete — thanks! Regarding item No. 3, this suggests also that certain kinds of insulation-strippers could be modified for crimping. These would be lighter to handle than pliers, and some have an adjustment for pre-setting the gap.

"WE SHALL FIGHT IN THE STREETS"

Guide to
STREET FIGHTING

GROUND—DEFENCE—ATTACK—USE OF EXPLOSIVES—ARMS AND EQUIPMENT—TRAINING—EXERCISES

BY

CAPTAIN S. J. CUTHBERT
Scots Guards

ILLUSTRATED BY JOHN G. WALTER

PREFACE

To say that street fighting has been neglected is an understatement too dangerous to be pleasant.

Consider, on the one hand, the military importance of towns. Leave out of account the fact that all governments reside in towns, that all vital industries are concentrated in towns, that all military dumps and depots lie in towns. Forget that nearly all good landing-places round our shores are, because they *are* good landing-places, built over; or that the Navy depends for its command of the oceans upon ports and naval bases, one and all of them cities. Overlooking these, remember this one fact, namely, that all road and rail communications pass through towns. Stop, and digest this fact. Think for a moment of the system of supply to an army; then return to this fact —all road and rail communications pass through towns.

Consider, on the other hand, the advantages of the defence in towns. Notice how in the recent war towns have held out long after the country round them has been overrun. Consider how the enemy official doctrine teaches that towns shall be by-passed and attacked later by troops specially detached for the purpose. They recognize that a town is a strong point, and they follow their doctrine of by-passing the strong point. But note that they also recognize the necessity of attacking the town. The reason is this: that both their armoured divisions and their infantry divisions depend for supplies upon wheeled vehicles: those vehicles run on roads and rails; and —all road and railway communications pass through towns.

No doubt towns are vulnerable to air and artillery bombardment. Experience seems, however, to point to the need for great air superiority if a town is to be made untenable. For examples of this, we need not look to Madrid, Tobruk or Odessa; we can remember the daylight *Blitz* on London. No one who witnessed Cockney courage and stoicism is likely to forget it; but the decisive fact which saved London was the German failure to gain air supremacy. And if an overwhelming concentration of air and artillery force has to be collected each time a town is encountered, lightning advances will be a thing of the past.

Possession of a town maintains a grip upon the lifeline that can strangle an offensive. Towns are the ready-made answer to the *Blitzkrieg*. Properly held they *must* slow an advance.

CHAPTER I

THE GROUND

CONDITIONS dictate methods: the fittest survive, because they best understand and adapt themselves to the conditions in which they live.

Street fighting is carried on in unique, unnatural conditions; *only* the fittest survive. It is above all necessary to analyse and understand the peculiar features of ground which go to make street fighting such a highly skilled form of warfare.

It is difficult in thinking of cities to discard the many familiar details and to focus upon the simple features which alone are of military significance.

i. The ground upon which most towns are built was the ground that covers England; the ordinary slightly rolling land, intersected by rivers, streams and hedgerows, and patched with woods. The woods and hedges have for the most part been cut to make way for masses of human habitations, but every town retains small areas of park and woodland.

ii. Vast human effort has gone to the perfection of communications in urban areas. Today towns may, generally speaking, be said to consist of, alternately, rows of houses and means of communication to them, here and there cut by railways, canals and other lines of communication.

iii. In the masses of homes that have been built, wealth has drawn distinctions.

The rich, though they may work in towns, generally choose to live in the country. Where, owing to the size of a city, they cannot easily escape, they occupy a central position. They build their houses strong and big, either detached and standing in their own grounds, or in rows surrounding a railed square of lawns and gardens.

The houses of the poor are usually situated near a great factory or industrial centre. Normally they consist of lines of small, two- or three-storeyed houses, ill-built, on either side of wide, straight streets, backed by little yards and the rear of another row of houses. These yards are usually a conglomeration of fences, sheds, shelters, bins, and other forms of obstacle and cover from view.

From the early nineteenth century onwards, unprecedented growth of population and industry demanded masses of hastily built houses for the new middle and lower middle classes. The advent of town planning and the fact that whole areas were built over by one firm gave us the modern suburbs which have grown round the outside of nearly every town. They consist of rows of small "semi-detached" or detached, lightly built, two-storeyed houses, standing between front and back gardens, fitting in a large design of criss-crossing streets. An enormous number of hedges and fences have been built to enclose these properties, so that back gardens offer both good cover from view and, cumulatively, great obstacles to an advance.

Spaced throughout the cities are shopping and commercial centres, usually consisting of very tall, strongly built houses, flanking main arterial streets. In many cities building has followed the haphazard lay-out of old centres of commerce, and we find the same buildings facing each other across narrow, winding streets, flanked by alleyways and passages.

Whatever the class of house or area, three generalizations can be made which are of the most vital importance, giving rise as they do to the basic principles of street warfare. It is these three features which must be understood, and digested:

i. No other type of country is either so open or so close. In every street are coverless stretches, ideal fields of fire, death-traps to the unwary attackers. Bordering every street are a hundred protected firing positions, a hundred hiding-places, a hundred ambush positions.

ii. It is possible to climb 30, 50, perhaps 100 feet in as many seconds. Street fighting thus possesses a third dimension, not often present in field warfare.

iii. Cities present exceptionally blind and disjointing conditions. In no other form of warfare are there such narrow horizons, or such ruthless divisions between units of the same force.

In this chapter it is not intended to discuss the rules of good street fighting. One such may, however, be given pride of place, for upon its unvarying observance depends not merely the life of any particular soldier but the attainment of the object he is ordered to achieve.

It has been said above "No other country is either so open or so close." It is well-nigh impossible to be more than five yards from cover.

This is the rule, and it is shared with field warfare; but it is more urgent, more emphatic!

USE COVER. NEVER HANG ABOUT IN THE OPEN!

CHAPTER II

THE DEFENCE

1. General

In the first chapter, the military features of built-up areas were analysed. In this and the following chapters conclusions are drawn from them, which form, so to speak, rules of conduct: and suggested methods of obedience to them are laid down. How many of these methods are put into practice must depend upon the precise nature of the attack and the time allowed for defence.

2. Forms of Attack

In this country two conditions of attack seem likely to present themselves. For the first, the regular land advance, the defender will probably have ample time to prepare a formidable reception.

The second type of attack allows no time for preparation. A company of enemy parachutists can land on a green space three hundred yards square and be ready to move or fight in under fifteen minutes. This will allow no time for elaborate booby traps, barricades or wiring.

3. Distribution of Forces

The first problem facing any unit commander is that of the distribution of his forces. The terrain offers the attacker a great variety of covered approaches, all of which must normally be stopped. If, however, he merely divides his force equally between streets he will succeed only in weakening the defence of them all. It follows that he must weigh the needs of a fixed defence against those of a mobile reserve.

The object of having a mobile reserve is, of course, to be able to concentrate a force at a point attacked by the enemy, either for counter-attack or reinforcement of the local defenders.

Against a land attack there may be time to make elaborate preparations for defence. If there is such time the defence can be made overwhelmingly strong and a large mobile reserve should not be necessary.

Against an attack by paratroops it is most unlikely that any preparations for a fixed defence could be made. The method forced on the defenders would seem to be to contain them by lines of "stops" and then clear the area enclosed—in other words, to become the attackers.

It should always be borne in mind that except at night or in thick fog, or where an ideal covered line of approach exists which the enemy are unlikely to cover, the sacrifice of the advantage of stillness conferred upon the defence is justified only by necessity, or to obtain surprise against a badly trained enemy.

4. Siting the Defence

In placing the members of any unit, the following points should be borne in mind.

i. The system of defence must pivot round the L.M.G. In built-up areas fields of fire tend to be very narrow. The high rate of fire of the L.M.G. makes it a weapon of inestimable value.

ii. The 360° field round any house is normally split into several narrow fields of fire. Riflemen should be used to cover all but the most important approaches.

iii. "Interior lines" abound in built-up areas. The distance between the defence of one street and the defence of the next is often the width of a house. Full advantage should be taken of this.

iv. It is easier to fire to one's left than to one's right. When firing to the left, the rifle comes out of a window before the body: when firing to the right, the body must be exposed before the rifle can be brought to bear.

v. In every street there are hiding-places in which men may lie low until the enemy has passed, and open fire from behind. If these men wish to fire to their left they must be on the side opposite to those prepared to fire on an approaching enemy. These two parties can therefore have the additional task of covering each other's doorways.

vi. Two men are far more than twice as strong as one, both for psychological reasons and because there are four sides to a house and at least two lines of approach.

On the other hand, a whole section placed in one house will find themselves surrounded without having been able to fire, unless sections are very plentiful.

It can be taken as a guide, therefore, that a house should be held by never less than two men and rarely more than five.

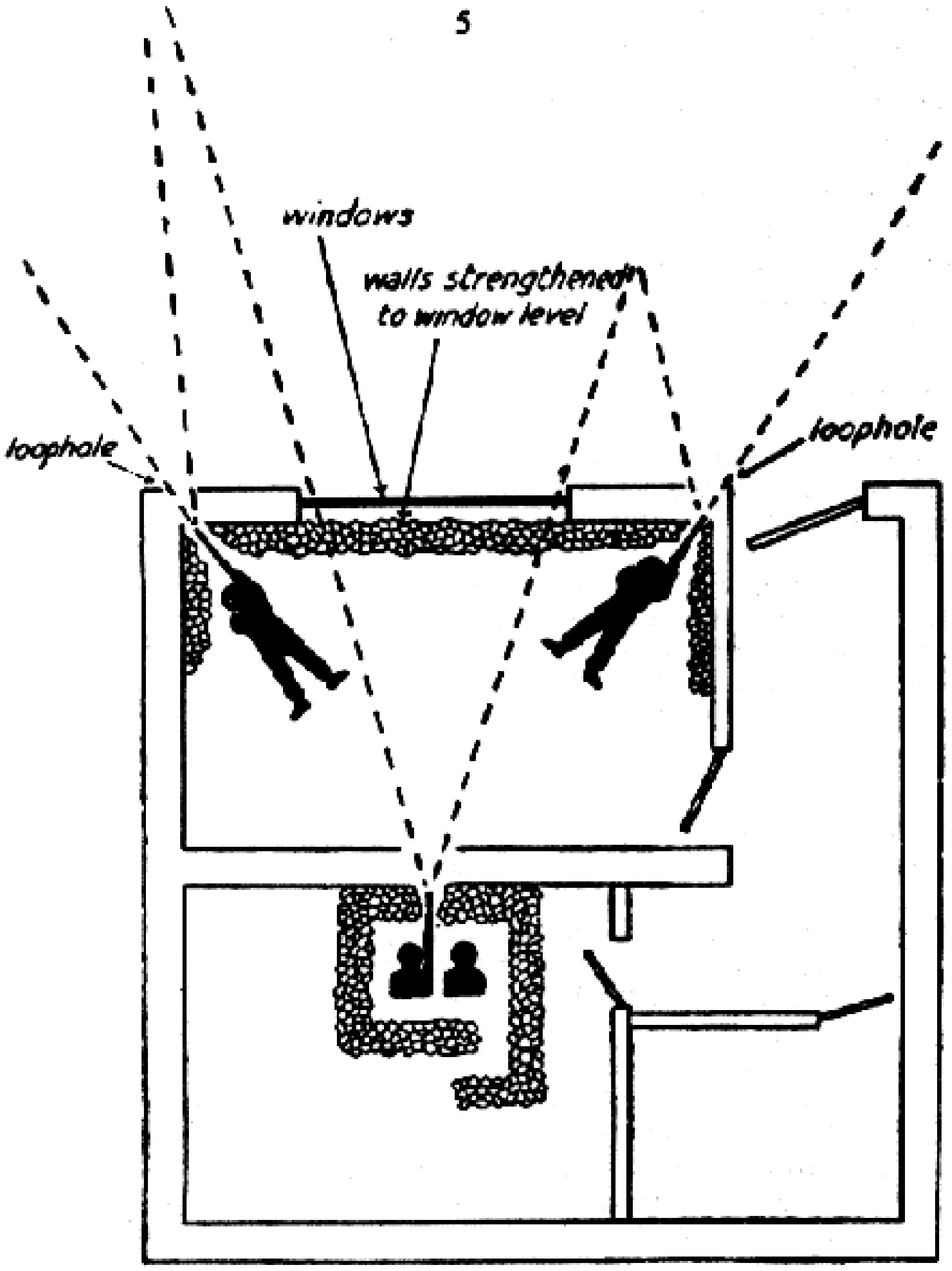
vii. The L.M.G. should be sited in a house selected for its dominant field of fire, its strength of construction and its unobtrusive position. Normally the house which is selected is at the end of a street, looking down the street, satisfying the first condition at the expense of the third.

From a corner house it is possible to fire in three directions. Although often desirable, such a selection does not avoid the obvious: the position must therefore be made very strong, and alternative positions prepared.

A house lying farther back from the road than its neighbours will often have the priceless advantage of being shielded by them from enemy covering fire.

viii. German street-fighting tactics are based on an attack from the rear. It is essential, above all else, to have all-round defence.

5



Method of widening field of fire, while ensuring unobtrusiveness.

N.B. Barricades, mines, & other personnel are not shown

6

5. Preparation of a House for Defence

Given time, there is practically no limit to the number of improvements which can be made to a defensive position in a house. Below is a long list of possible improvements. It is obvious that in very many cases time will not allow for all of them to be carried out. It should be equally obvious that it would be criminal on that account to ignore them.

Fire positions have been selected:

i. For their good field of fire.
ii. For strength.
iii. For unobtrusiveness.

These three characteristics of a good defensive position should be exaggerated in every conceivable way.

i. Good Field of Fire.

(*a*) The best field of fire is obtained from the lowest possible firing position. Many houses have basements whose windows just clear the surface of the ground: these should be used if possible.

In other cases a ventilator may be enlarged or a loophole knocked in the wall.

(*b*) The farther forward the L.M.G. is placed the wider will be the field of fire: on the other hand, the more vulnerable will it be. If it is necessary to have a wider field of fire, loopholes may be made in the side walls for riflemen.

ii. Strength.—Every fire position can, given time, be made proof against the collapse of the house in which it is sited.

(*a*) Remove breakables and inflammables, *e.g.*, window glass, ornaments, curtains, rugs, etc.

(*b*) Send a man round the neighbourhood commandeering fire extinguishers, water buckets, etc.

(*c*) Shore up the fire position.

(*d*) Build an emplacement.

1. These can be made of sandbags or rubble between boards, in chests of drawers, etc. The emplacement should be roofed over with timber: joists taken from another room are suitable.
2. The emplacement must have a solid foundation. It will generally be necessary to remove part of the floor (see Appendix II).
3. A man fires over the following heights:

Rifle or L.M.G.:

Standing	4 ft. 6 in.
Kneeling or sitting	30 in.
Lying	12 in.

7

M.G.:

Sitting	24 in.

4. Inside dimensions:

6 ft. long.
3 ft. 6 in. wide.
5 ft. high.

5. Loopholes: build them with narrow exits, widening towards the inside to allow for traverse. Duplicate them freely, as they are impossible to hide.

(*e*) All entrances must be barricaded or, where it is impossible to hide a barricade, mined. This applies to all doors and windows. Booby traps should be laid in the hall and on the staircase.

(*f*) A line of withdrawal must be left. In the case of attached houses, go next door, find a cupboard on the party wall, and knock a hole in the back into the defended house; then close the cupboard. With detached houses knock a hole into a lean-to shed or bush: or lean a wheelbarrow, bin or other article against the hole. If necessary place a dummy booby trap over the hole.

(*g*) Knock loopholes in walls to cover every approach to the house: a loophole from the occupied room to cover the front hall is also useful.

(*h*) Find some fine wire-mesh and wire over all the windows to prevent grenades being thrown in. Cut a slit in the wire to allow the dropping out of grenades.

(*i*) Make a dummy position. A bolster hung on a wire at the back of a room three doors away can be connected by a wire run through the intervening walls. A jerk may deceive, and will certainy distract, enemy observers.

(*j*) Prepare an alternative position. The Germans used tracked guns to blow a house to pieces; no amount of strengthening will withstand a direct hit.

(*k*) Make a gas-proof room and stock it with candles (the electric light is bound to fail), torches, water, medical and food supplies, and ammunition.

iii. Unobtrusiveness.—When all improvements to the field of fire and strengthening of the house are complete, it is essential to remove any clues which may betray your position to the enemy.

There are two principal methods:

(*a*) *Concealment.*

Be sure there is no external sign of a barricade.

Remove the trail of sand and rubble which almost certainly leads up to the door.

Put muslin curtains over the windows. They are opaque from the outside and transparent from the inside—besides being the very symbol of respectability.

(*b*) *Duplication.*

Work which cannot be hidden must be duplicated.

If yours is the only door in a damaged street which is tight shut (to conceal a barricade), shut others in the street.

Clear of glass the windows in half a dozen houses, and wire them over.

Make dummy loopholes in your own house and in the houses whose doors you have closed and windows you have cleared of glass.

If the field of fire has had to be cleared so much as to become obvious, treat the other houses in the same way.

6. Positions other than in Houses

Having considered the defence of a house at such length, one is apt to forget that there are in built-up areas other excellent positions. Slit trenches offer better cover against air and artillery bombardment than any house: they are not, however, useful against a land attack, as they can be commanded from the upper floors of neighbouring houses.

In street fighting one expects the enemy to take refuge in houses. A thick hedge, the branches of a tree, a heap of refuse, a pile of rubble may all provide excellent surprise positions. It must be quite clear, however, that most of these positions depend upon concealment: discovery will render one as vulnerable as if one were standing motionless in the middle of a street.

7. Anti-Tank Defences

Tanks suffer from serious handicaps in built-up areas, for the following reasons:

i. The enemy can erect road blocks which cannot be seen from a distance.
ii. The enemy can remain concealed until a tank is directly beneath his position.
iii. Tanks cannot fire more than, at an average, 30 degrees above the horizontal.
iv. Visual contact between tank units is lost, and direction is very hard to keep.

It is clear, however, that they suffer from these handicaps *only* as long as the enemy is prepared to take advantage of them.

The most suitable positions for an ambush are:

i. On the upper floors of a strongly built house.
ii. Above a road block or a point where the enemy is likely to stop at first sight of a road block.

The same weapons may be used against tanks in streets as in the fields. The third dimension in street fighting and the fixed nature of the defence are ideal for the use of the heavier grenades, such as the No. 73 or the S.I.P. grenade.

For a list of anti-tank weapons and their characteristics see M.T.P. No. 42 (1940).

8. Street Obstacles

i. Trenches, or barricades, of wagons, cars, furniture, etc., may be very useful in holding up enemy troops or vehicles, especially if placed just round a corner to effect surprise. They are not, however, effective as fire positions because they can be commanded from the tops of buildings. They should be covered by fire from a neighbouring building and not used as a breastwork.
ii. Wire is the best possible obstacle to advancing troops. A street properly wired and covered by an L.M.G. is a death-trap. It forces the attacker to commit the great, and invariably the last, sin of street fighting—hanging about in the open. Wire should be placed far enough away from the defended house to prevent the enemy throwing grenades and should not be so laid as to give away the position of the house to the enemy. Tins with pebbles inside should be hung on the wire to raise the alarm should the enemy try to remove it under cover of darkness.

CHAPTER III

THE ATTACK

1. Forms of Attack

Broadly, attacks in built-up areas have one or both of two main objects:

i. To penetrate to a certain area.
ii. To clear a certain area of enemy.

It is impossible to say what precise forms attacks in cities or towns will or should take. They will vary with the object, the ground, and other particular circumstances.

The following is a general impression of the lines which a modern attack may follow, and is intended more to stimulate thought than to prophesy events.

The process may be one of neutralization and infiltration.

i. The town is subjected to heavy bombardment by aircraft or artillery, or is sprayed with gas. The main enemy body may by-pass the town, leaving its capture to special troops detailed for the purpose. The latter will probably attack the town as soon as the bombardment ceases, from any direction they judge to be favourable.
ii. As a result of reconnaissance and careful study of the town plan, certain few buildings or localities well inside the town may be selected as first objectives. At first small and then large parties of troops will force their way to these objectives to form strong points from which the core of the town may be eaten out and any perimeter defences attacked from the rear. The objectives will be selected so as to be co-operative, *i.e.*, success in training objective A will aid those troops who are trying to gain objective B.

2. Methods of Attack

The scheme of attack tabulated below has been laid down *not* in order to dictate hard-and-fast rules to an attacking force but in order that a clear idea may be obtained of the problems facing an attacker and of a reasonable solution to them. It will almost always be impossible for the attacker to keep completely to the ideal. The chaos attending street fighting, and the haste imposed upon all commanders will demand a compromise: if this compromise is to be successful, initiative and a high degree of training are required of all ranks.

Failure to realize the inevitability of disorganization and chaos would be dangerous. It must be accepted that commanders will lose

control of their units, that members of the same unit will lose touch with each other and may even fire upon one another, that direction will be lost and pockets of enemy exist behind the forward attacking troops.

Under such circumstances:

i. A simple plan is essential. Each unit must be given a clear limited objective, and complicated manœuvres such as a change of direction should generally be avoided. Isolated thrusts apart from the main attack are not usually successful and will not divert as many defenders from the main attack as might be achieved in field warfare, since the bulk of the defence will probably be on a fixed system giving all-round defence.

ii. Success or failure will largely depend upon the initiative of subordinate commanders. Lacking clear orders as to their next actions, section and platoon commanders must on no account merely send back each time to be told what to do, but must act swiftly and with enterprise in the spirit of their previous orders. Speed in attack must not be allowed to flag for an instant. The need for a clear limit of exploitation, however, referred to in sub-para. (i) will now be even more clearly seen.

iii. Accurate, early information is vital. A plan made with insufficient information will fail; a plan made with incorrect information will fail. A sub-unit commander has not done his duty if his superior commander does not know everything about the enemy that he knows, and all that is required about his position, intention, casualties and state of exhaustion.

iv. Tremendous thrust is required. In this difficult terrain, the attackers are forced to move in the open against defenders who, given time to choose and perfect their fire positions, can make them feel like rabbits in a wood, continually surprised and shot at from unexpected directions. The attackers can upset the scales only by giving their opponents no time to prepare, no rest in retreat, no chance to reorganize or reassure themselves. Speed is of the essence, and speed can be produced only by intelligent anticipation, efficient orders, dashing execution, and energy, more energy, and energy again.

3. Advance

It is usually impossible absolutely to safeguard the main body against attack. An active advance guard will, however, use some of the many good points of observation that abound in cities, cover with fire the more important junctions, and question inhabitants.

The main body should be well deployed. It may often be best to keep all sections on one side of the road, for two reasons:

i. They can keep to the shadow.

ii. In the event of a sudden attack, they will all take cover on the same side of the street, and will not therefore be divided from each other by a coverless, bullet-swept area.

4. Protection

From the start to the end of operations there must be no moment during which the main body can be surprised undeployed. On arrival at the assembly position, whether on foot or in M.T., O.Ps. and sentries will be posted covering every approach. Two A.A. sentries per company should be posted in an open space or square covering opposite arcs of 180°. The main body should take immediate cover and be slightly dispersed.

5. Reconnaissance

Horizons of brick and mortar make reconnaissance difficult. The ideal of an aeroplane view being usually denied, second best is a view from a high building. Other useful aids are street maps, aeroplane photographs, and the accounts of troops on the spot, and local inhabitants. Officers commanding troops likely to be used in built-up areas may find it useful to obtain aeroplane photographs of their area for use instead of maps.

6. Plan

In forming his plan the commander must bear the following points in mind:

i. A complicated plan depending for its success upon co-ordination between troops attacking up widely separated streets, or upon changes of direction, is liable to fail.

ii. Streets provide easier and quicker lines of approach and attack. Back gardens may sometimes offer more cover: but it should be remembered that it will often be necessary to climb over obstacles, and at these moments exposure is unavoidable.

iii. A single attack should be maintained. This does not mean that only one street or one house is to be attacked at a time. It does mean that if two or three or six streets are attacked at a time the effort should be co-operative, *i.e.*, success in street 5 helps the troops attacking street 1.

7. Headquarters

Headquarters should be chosen for the following features:

i. Well up: much closer to the forward troops than in field warfare.

ii. Easy to find.

iii. A strongly built house or shelter.

iv. Entrance and exit defiladed from enemy view and fire.

No concentration of troops or M.T. must be allowed near it, by day or by night. During an attack it may frequently be necessary for the Headquarters to be moved. Chalk or other marks may be drawn as a guide to the new Headquarters. For safety it can be arranged beforehand that, *e.g.*, arrows face the opposite to the true direction.

8. Cordons

The object of cordoning is to prevent enemy lateral movement, whether of reinforcement, counter-attack or escape.

When the object of an attack is to clear an area of enemy, the procedure should be to cordon a sub-area, clear it, and keep it cordoned from the uncleared area.

When the object of an attack is to penetrate to an area, it may frequently be advisable to cordon the line of advance.

Cordoning should be carried out by fire, not by men. The firing position should be selected so as to give the best field of fire, and will therefore normally be as low as possible.

9. Covering Fire

It should be an absolute rule that no troops move across the open until three measures have been taken:

i. A rifle or L.M.G. must be sited to cover the street in which they are moving. In choosing the firing position, bear in mind:

(*a*) That if the enemy see you getting into position or if your position is the obvious one to choose, you will never fire from it.

(*b*) That S.A. fire penetrates up to 13½ inches and .55-inch anti-tank rifle fire up to 27 inches of brickwork, and that prolonged bursts will achieve greater penetration.

(*c*) That the lower you are the longer will be the beaten zone of your weapon.

(*d*) That if you are going to cover the advance of your own troops from the rear you must get high enough up to fire over their heads until the last possible moment.

(*e*) That there are many good firing positions other than in houses.

(*f*) That fire from a position rather above a room occupied by the enemy will search the position best and is the most telling.

For details of fire positions from a house, see Chapter II.

ii. One L.M.G. per company should be sited on one of the highest buildings in the area to cover as far as possible all rooftops. It is very hard for troops in streets to deal themselves with attackers above them. No street should be attacked without domination of the rooftops.

iii. There is usually a house whose windows dominate a whole street. It may be placed at the end of the street, or on rising ground farther away. If there is such a house, make preparations before attacking the street to destroy or blind it if the enemy should open fire from it.

10. The Point Section

The first troops to break cover are the point section. This consists of:

i. *Scouts.*—The duty of the scouts is to find out where the enemy is. They move, one or two on each side of the street, by short bounds, stopping under the cover of doorways, buttresses, gateposts, alleyways, etc., to observe the opposite side of the street. When moving, they should keep as close to the side wall as possible, and must go at the highest possible speed. During their pauses for observation they must on no account keep their heads poking round a corner; if possible they should be equipped with periscopes. If fired on, the scouts should take cover and try to work into position to give covering fire to the assault party.

ii. *Observers.*—Behind the scouts move the observers. Their duty is to observe and report on any enemy movements. The normal number is two for each side of the road. This is a minimum, for should there be anything to report one must go back, leaving one to observe. Like the scouts, they should move rapidly, and close to the side walls. They should be so far up that they can see what is happening to the scouts; and so far back that they are not exposed to the same fire as the scouts, and can get back to report. If they are pinned to cover by enemy fire they can usually shout back a message. A catapult is a possible method of sending back a message to the end of the street.

In the case of the enemy opening fire the message should contain:

(*a*) Strength and armament of enemy.

(*b*) Exact position, side of street, number or description of house, first or second floor, right or left window.

(*c*) Whether a scout is in position to give covering fire.

(*d*) What possible covered approach there is to the house.

iii. *Remainder of the Section.*—Under the N.C.O. the remainder of the point section works along behind the scouts and observers, helping to search out the enemy or protect the section. A man may be sent down a cul-de-sac or a little passageway between houses to look to a flank. Another may be posted to cover a street running off to a flank. A third may be used to cover the scouts and observers when they have got rather far from their previous covering fire.

It may be necessary to strengthen the point section. This should be done when the point section is likely to have far to go.

11. Mopping Up

It must not be thought that because the point section has encountered no opposition a street is clear of enemy. In every street there are enough covered positions to conceal a battalion.

If the street is to be cleared, as soon as the point section has covered a sufficient distance:

i. Arrangements should be made to cover the backs of the houses on each side of the street with fire, preferably L.M.G. fire.

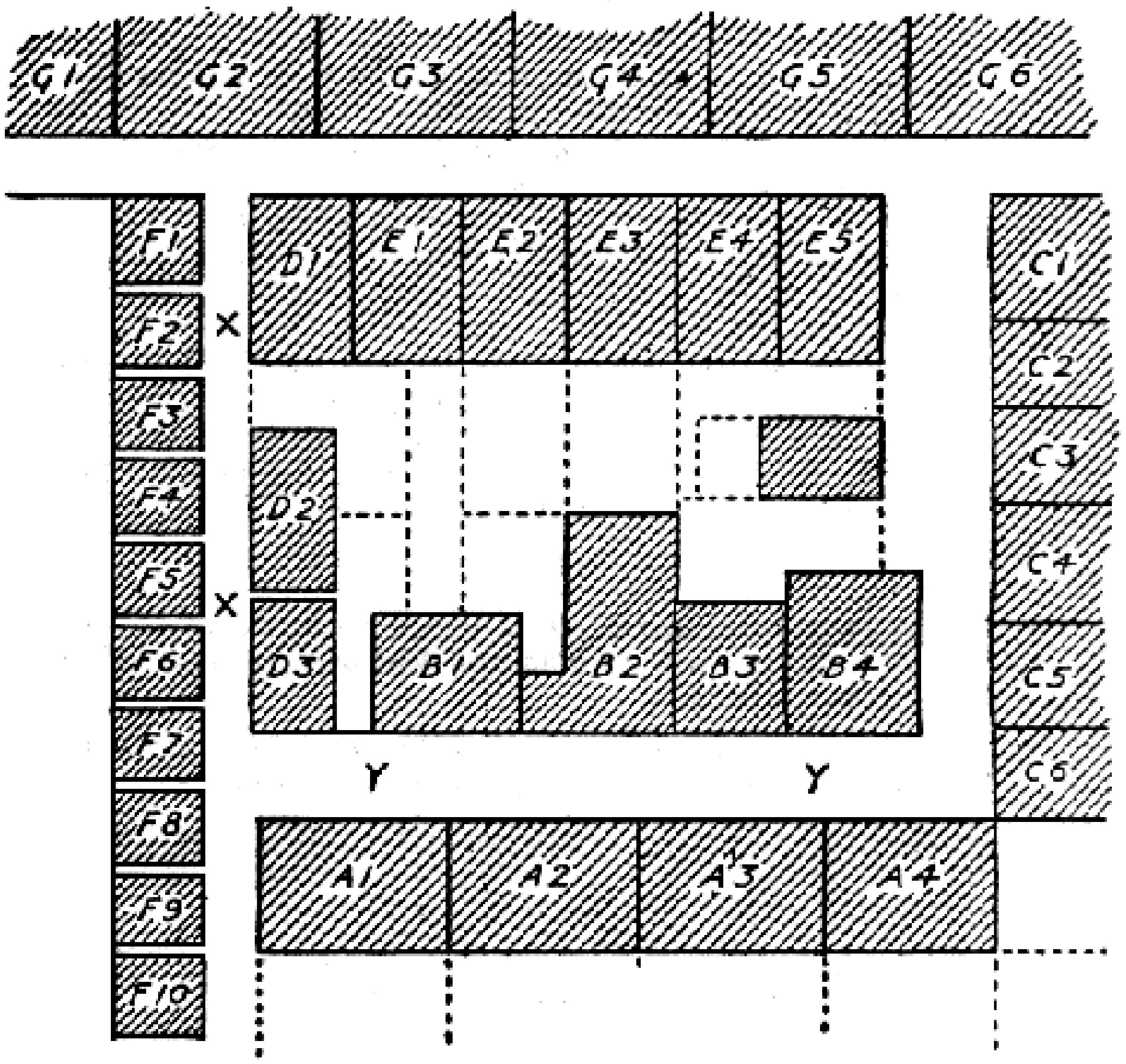
ii. The two rear sections should advance, one on each side of the street, searching the houses. The N.C.O. should remain in the street controlling operations, while his men, working in pairs, pass rapidly from house to house. The search need not be thorough, for a single enemy concealed in a cupboard will be cut off from his friends and in no mood for a stout resistance.

12. Consolidation

It is not usually enough to clear a street; it must be held, to prevent enemy reoccupation or counter-attack. Normally only a single rifleman can be spared, for there may be many streets, and men and weapons will be at a premium.

13. Assault

i. *Forms of Attack.*—When the enemy is encountered he must be dealt with. There are many forms of attack. He may be attacked with bombs from the air; though this form is not practicable in close fighting, and is more useful against an area than against an individual target. He may be attacked with shells from a gun man-handled into position; with A.P. weapons capable of riddling his protective cover; with incendiary weapons fired or thrown; with gas; with *any* effective weapon from a gun to a hosepipe. Often, however, it will not be possible to oust or destroy the enemy without



Walls are marked thus ⌊___⌋

Fences - - - ⁞.......⁞

Houses - - - *A1, B4, E3 etc*

Streets - - - *X, Y.*

an infantry assault, and it is the infantry assault, whether combined with other forms of attack or not, with which we are concerned.

ii. *The Lines of Assault.*—In the same way, there are many lines of assault. An assault may be made up main streets; up side streets, through back gardens; over rooftops; through neighbouring houses; through a house opposite and across a road; possibly even through sewers or contiguous cellars. Gliders were used by the Germans in Belgium to land on a wide, flat roof at Fort Eban Emaal. We may leave out of account these more exotic forms of attack while remembering that if they are possible to do they will be a surprise, a *new idea*, and therefore successful. In deciding upon a line or lines of assault the following points should be borne in mind:

(*a*) An enemy position is a strong point. Before it is attacked it should be as nearly encircled as possible. Occupy the houses on either side or behind it.

(*b*) Gain the houses on one side of a street before you enter the street. Example (see diagram opposite): A and F are occupied by our own troops. Enemy in B will find it hard to cover the B side of the street and will have to lean right out of the windows, doors, etc., to do so, where they will be themselves exposed from A2, 3 and 4. Thus the street can only be effectively covered by the enemy from C, and this narrows the opposition almost to a single house, which can be neutralized.

(*c*) Attack the enemy most threatened by your own position. Example (see diagram opposite): A and F are held by own troops. Which street should be made good first—X or Y?

Analysis: one side of each street is held. One end and one side of each street is held by the enemy. Of the enemy houses holding X, D2 and D3 are covered by fire on four sides, and D1 is covered on two sides. Of the enemy houses holding Y, four sides of all the houses D3 and B1, 2, 3 and 4 are covered by fire. Moreover, the street joining X from the enemy side is not properly covered, whereas the entrances to Y are well covered. Conclusion: street Y should be attacked first.

(*d*) More than one line of attack will be found difficult to coordinate but will have an excellent psychological effect upon the enemy.

(*e*) If you can attack along a line which does not hinder your covering fire the latter will be more effective.

(*f*) Back gardens may offer good cover: advancing troops will, however, find it difficult to avoid exposing themselves when surmounting obstacles.

(*g*) It is hard to deal with attackers from above; rooftops are safe from below, and, being built as a rule in the shape of an inverted V, they have usually a side defiladed from fire.

(*h*) In the case of an attack through houses, back doors a little distance from the enemy house are usually covered from view by high wooden fencing, sheds, etc. Moreover, in "jerry-built" houses it does not take more than a minute or two to knock a hole in the wall.

(*i*) The most suicidal occupation in war is to delay in the open.

(*j*) The enemy are unlikely to occupy a single house unsupported by any other position. Normally they may occupy houses on each side of the road and site their L.M.G. in a house whose windows dominate the whole street (see Chapter II).

iii. *The Assault.*—Experience in Madrid showed that a very high proportion of the total casualties was incurred in assault, and of these 75 per cent. were caused by delay outside the barricaded house of the enemy. The whole assault must be carried through at the highest possible speed by the shortest exposed route, with the heaviest possible covering fire until the last possible moment.

The following points should be considered:

(*a*) The enemy will prefer firing to his left. Firing off the right shoulder he has to expose his body less when firing to the left than when firing to the right. Incidentally, the greater the angle to his position, both lateral and vertical, at which he has to fire, the more must he expose his body.

(*b*) The enemy will undoubtedly have barricaded or mined all entrances to his house. Preparations must be made to force an entrance to the house with the shortest delay outside. The best method is for a single man to run forward under covering fire, place an explosive against the house and dodge under cover. He should avoid

doors and windows in placing his explosive; possibly a point in the side wall is best. (For the most suitable explosives and methods of use, see Chapter IV.)

If explosives are not obtainable, second-best are a heavy axe and a crowbar. Their employment means delay in the open and should be avoided whenever possible. Then men who are using them should always be accompanied by a man watching for bombs and grenades thrown from windows or a roof, ready to seize and throw them over a wall or down the street.

If explosives are used to force an entrance, the remainder of the assault party must be under cover well up, ready to dash in before the enemy has recovered from the shock of the explosion. Whatever the method employed of forcing an entrance, the assault party must attempt all methods of getting in. They need not necessarily confine themselves to going in through the gap they have made; the enemy will be concentrating their attention on it, and a man going in over the roof of a lean-to shed, up a drainpipe or down the skylight may escape notice.

(*c*) *Clearing the House.*—Having made an entrance, the assault party still has half its task before it. Before leaving cover to assault the house, the officer or N.C.O. in charge must allot tasks to each member of his party to ensure that there is no hanging about inside the house and that no room, cellar or attic is unsearched.

The following points should be borne in mind:

(1) The house should be searched systematically, floor by floor, remembering the cellars and roof. It is better if possible to search a house from the top downwards, as this makes an ally of gravity for grenades, etc. It does, however, involve entrance from the roof.

(2) The front hall and the staircase are the two most dangerous points. Try any method of getting up and down from floor to floor but the main staircase. If it is not barricaded it will certainly be mined. The fire escape may help. If the staircase must be used, feel in front of you with a long pole or throw a grenade at it, to set off any booby traps.

(3) The officer or N.C.O. must stay in the hall or passage to direct operations, but he must make use of any cover there may be, *e.g.*, a thick sofa.

(4) If the enemy are known to be upstairs, a few bursts of S.A. fire through the floor from underneath will be a prudent action.

(5) Smoke grenades inside a house are quite overwhelming. Incendiary bottles or bombs are very intimidating. (For arms and equipment suitable, see Chapter V).

(6) Prisoners can be used to clear the house by setting off or revealing booby traps.

(7) Enter a room crouching as low as possible. The enemy will be prepared to fire about three or four feet above the floor.

It is essential that all attackers are familiar with methods of defence outlined in the chapters on defence and booby traps.

CHAPTER IV

THE USE OF EXPLOSIVE

1. General

The use of high explosives can solve many of the problems that arise during street fighting with an ease that astounds those who have never seen this weapon in action. It is essential, however, that only those who are trained in the preparation and application of H.E. charges are permitted to handle it.

The training itself is a simple matter and requires only average intelligence and determination on the part of the student. Methodical habits combined with reasonable enthusiasm are preferable to headstrong and suicidal dash, as, both in preparation and handling, explosives call for care and a steady head lest they become a source of danger to the user and his comrades. Arrangements should be made to have two or three men from each platoon trained in this subject, as they will be invaluable when the opportunity to use H.E. arises.

In the course of this chapter high explosives only are referred to, a classification which excludes gunpowder. Methods of handling are not given, as practical training is essential in this subject. The chapter confines itself to suggesting some of the tactical uses of H.E., both in defence and in attack.

2. Types of Explosive

The principal explosives now in use are:

i. *Gelignite*.—A plastic explosive of high power, suitable for all cutting operations, usually coloured buff, grey, brown or yellow. It is commonly supplied in 4-oz. sticks and can be initiated by a detonator only. It requires careful storage to avoid deterioration, and has definite temperature limits of 32° F. and 110° F. It must always be stored in a dry atmosphere. When placed in position and left for any length of time it must be well protected from damp.

ii. *Guncotton*.—The safest of all explosives in Service use, it requires a primer to initiate it. Packed in air-tight tins it can be stored more easily than gelignite and it does not deteriorate readily. It is not so powerful as gelignite, but can be used for all cutting operations, the main disadvantage being that it is issued in 1-lb. blocks and is not plastic.

iii. *T.N.T.*—A compressed powder issued in 1¼-lb. blocks, it is comparable in use and application with guncotton. One block of T.N.T. will have equal effect with one block of guncotton. T.N.T. is easy to store, but has the disadvantage that the blocks are brittle and crumble easily. It requires a primer to initiate.

iv. *Explosive 808*.—An extremely powerful explosive issued in 4-oz. sticks. It has better storage qualities than gelignite and is even more powerful, but it requires a primer to initiate it.

v. *Ammonal*.—A grey powder, mainly used for cratering and other mining operations, it is the least powerful of all Service explosives. Its slow speed makes it most suitable for shifting large masses of earth, but it should never be used for a cutting or shattering operation. Ammonal must be kept perfectly dry, as the least degree of damp renders it useless. It is issued in 25-lb. and 50-lb. tins and also in 4-oz. waterproof cartridges.

3. Defence

As explained in Chapter II, it is unlikely that enemy tank formations will venture into built-up areas; it is more probable that infantry will be called upon to capture a town.

All houses which are adapted for defence should be fitted with a booby-trap system, operated electrically. The whole system can be controlled by a master switch which is situated so that the last defender can make the system live as he leaves. Booby traps will not be suspected in a house which has been used for defence, and the ensuing casualties will cause the attackers to reduce their speed of advance—even if it does not force them out into the open. Alternatively, each house can be mined either by buried charges or by explosives concealed in the basement or ground floor. These charges can be fired from the neighbouring houses, and a single house blown up in this way will deter attackers from entering any other house near by with any feeling of confidence.

For details of booby traps see Field Engineering Pamphlet No. 9, Plates 16, 17, 18, 19, 23, 24 and 25, and the written material referring to these plates.

4. Explosives in Attack

When clearing the enemy from occupied houses the advantages of explosives are very evident. The approach to an occupied house can be made on a blind side, *i.e.*, the side where there are no downstairs windows. The house can be entered by a hole blown in this blind side, the charge required in most cases being surprisingly small.

If an entrance is made immediately after the explosion it will be found that the defenders in the immediate vicinity of the breach will be either casualties or in no condition to put up any resistance. Once inside the house, similar methods can be adopted to break into any room that offers resistance. Further, if a charge of 1 lb. of H.E. on a 5-second or 7-second fuse be thrown into a room occupied by the enemy, the mopping-up operation becomes extremely simple and safe.

German troops were trained in the use of pole charges, *i.e.*, charges of 10 lb. or more of H.E. on the end of a long pole, fired by an ordinary time fuse. These pole charges were intended to be placed in the loopholes of pill-boxes and were carried forward under cover of smoke or darkness. An adaptation of these charges can be made with advantage, and men should be trained to apply such charges to street fighting when clearing points strongly held by the enemy.

With an elementary knowledge of explosives it is a comparatively simple matter to clear buildings which can block a field of fire.

5. Anti-Tank Measures

Though the unsuitability of tanks in built-up areas has been stressed, it must on no account be taken that tanks will not be used by the enemy. Tanks are only unsuitable as long as every precaution has been taken against them. Every preparation should be made for their reception, and in this explosives play a large part.

Charges should be buried across all approach roads at a depth of 9 inches or a foot. The quantity of this should be 4 lb. per foot of length. The charge must be fired electrically and provision can be made to fire this from the cover of a neighbouring house. This charge will wreck lorries, but will only smash the track of a tank and bring it to a standstill. Though badly shaken, the crew will still be in a condition to fight and their guns will still be in action. To finish off the tank it is necessary to get a charge of explosive on the hull of the tank itself.

This can be done under cover of smoke or the charge can be lowered from the upper floors of houses near by. Arrangements can be made to have charges suspended above the road at suitable points or they may be lowered with the aid of long poles. The charges should, if possible, be placed on the rear deck of the tank behind the turret: though the thickness of the armour plating in this position varies, a charge of 10 lb. should smash a hole in the hull and disable or kill the crew. It is desirable to have some knowledge of the weakest parts of a tank's plating, and this knowledge should enable the charges to be placed to the best advantage. As an alternative to the continuous road charge, separate charges of 4 lb. can be laid in the same manner as anti-tank mines at close spacing, though they must be buried sufficiently deeply to prevent their being damaged by traffic. The separate charges should be connected up by instantaneous fuse so that they can all be fired simultaneously by a low-powered battery exploder.

In addition to these road-block charges, a number of 10-foot planks should be prepared with the appropriate quantity of explosive strapped to them. These portable road charges can be rushed to any threatened point and laid by the roadside suitably concealed. On the approach of tanks or armoured fighting vehicles these planks can be dragged across the road and exploded under the vehicle as required.

6. Demolition

Small bridges can be destroyed with ease and certainty, and craters blown in the road to form tank barriers. These and many other simple demolitions can be carried out after a short but careful course of training. It must be repeated, however, that H.E. must be handled only by trained men and that men should be trained without further delay. The possibilities of this weapon in trained hands are unlimited, but in the hands of untrained personnel its use is usually disastrous.

To sum up generally, a knowledge of the use of explosives places in the hands of a single individual the most powerful weapon in existence, a weapon which, handled with reasonable care and skill, is practically safe and adaptable to a very high degree. In using explosives it is not necessary to hold large stocks and kinds and sizes of grenades, each grenade being suitable for only one job. A single store of H.E. can be held and by varying the quantity used this one item of store can be adapted to a variety of purposes.

The final, and in fact ruling, point in the handling of H.E. is that personnel must be trained carefully and must at all times continue to observe the precautions taught in this training. Accidents will only create a loss of confidence in the weapon, whereas the loss of confidence should be in the operator. Provided this is borne in mind, the unit commander will find a solution to the majority of street-fighting problems in the use of H.E.

CHAPTER V

ARMS AND EQUIPMENT

General

The choice of arms and equipment should be governed by certain features of street warfare:

1. Street fighting imposes great physical strain upon all ranks.
2. Many obstacles are encountered in built-up areas.
3. Nearly all surfaces are hard and smooth: water drains off quickly.
4. Fighting usually takes place at close quarters.
5. There are usually many firing positions giving good cover from fire: most of these have overhead cover which can quickly be strengthened.

The above points suggest definite conclusions:

1. Arms and equipment should be kept as light as possible.
2. Weapons should correspond to one of the following types:
   - i. Giving a great volume of fire in proportion to weight and size, *e.g.*, a sub-machine gun.
   - ii. Being able either to get round or to penetrate cover from S.A. fire, *e.g.*, a grenade or Boys rifle.

1. Arms

i. *Rifle and Bayonet* (S.A.T. Nos. 3 and 12.)—The 360° field round any defensive position is likely to be split, in built-up areas, into several separate, narrow fields of fire. The rifle is the ideal weapon to cover the less important fields of fire. The bayonet is the principal close-quarter weapon for the ordinary rifleman, and can be used with great moral and actual effect in clearing houses, or in street *mêlées*.

ii. *Discharger.*—The present issue of one discharger per platoon is intended for the use of the No. 68 grenade (see below). For this purpose one rifle per platoon should be strengthened by binding.

iii. *M.M.G. and L.M.G.* (S.A.T. Nos. 4 and 7).—These two weapons will be dealt with together, as in street fighting the greater range and endurance of the M.M.G. will rarely be utilized.

Both types are excellent in defence and can make a street impassable. The L.M.G. is suitable in attack to give covering fire, but both are too heavy and cumbersome for close-range fighting, such as would be the case in gardens and houses. At a pinch an L.M.G. can be fired from the hip, and may be useful where sub-machine guns are not obtainable.

iv. *The Sub-Machine Gun* (S.A.T. No. 21).—This is the ideal assault and close-fighting weapon. It enables targets appearing from different directions and at short ranges to be engaged quickly, and has a high rate of fire combined with great stopping-power. The sub-machine gun can be fired from hip or shoulder with accuracy up to 50 yards. It has been found that the best method of firing from the shoulder is to align the foresight in the V formed by the cocking-handle rather than the backsight.

v. *The Boys Anti-Tank Rifle* (S.A.T. No. 5).—This has good penetrative qualities (see Appendix I), and, although primarily for use against A.F.Vs., can usefully be used against enemy behind cover proof against S.A. fire. The hole blown by the bullet will not be large enough to provide entry to a house. The rifle is rather heavy and awkward to carry great distances.

vi. *Two-inch Mortar* (S.A.T. No. 8).—This weapon is difficult to use and rather ineffective in built-up areas, for the following reasons:

- (*a*) Mortar bombs have little penetration.
- (*b*) The enemy will, in defence, be roofed over; and, in attack, will either be roofed over or better engaged by S.A. fire.

There are, however, occasions when it is useful to attack an enemy in gardens, ruined houses, etc., while it may sometimes be possible to use smoke, in cases where an O.P. can be found close to the weapon.

vii. *Pistol.*—In the hands of an untrained shot, the pistol will not prove an effective weapon. With constant practice, it will be found that the short barrel and the speed with which single rounds can be fired enable the firer to engage targets rapidly in different directions and render it a very useful weapon for close-quarter fighting.

viii. *No. 36 Grenade* (S.A.T. No. 13).—This grenade is no longer fired from a discharger, but when thrown is a most valuable weapon. It will normally be used in clearing a house and in surprise encounters with enemy at close quarters.

It has a 4-second fuse and can be thrown up to about 35 yards. The thrower must take cover before the explosion.

No. 36 grenades are *not* suitable as explosives to blow a gap in barricades, doorways, walls, etc.

ix. *No. 68 Grenade.*—This grenade is fired from a discharger on an E.Y. rifle. It has great penetrative power, but will not blow a large hole. The blast effect inside a small room may be very considerable.

x. *No. 69 Grenade.*—This grenade is in a light bakelite container and has a blast effect over a small area. Though its destructive qualities are not great, it has a tremendous moral effect, which makes it a useful weapon for fighting at close quarters. The thrower need not take cover after throwing.

xi. *No. 73 Grenade.*—This grenade, designed for use against A.F.Vs., has great destructive qualities, and will therefore be useful against walls, etc. It can be thrown up to 20 yards. The thrower must take cover.

xii. *The S.I.P. Grenade.*—Incendiarism is an effective form of attack on emplacements, houses and A.F.Vs. The S.I.P. grenade has therefore a distinct value in street fighting. A minor advantage is the smoke it produces, which may temporarily blind the enemy and force him to put on a respirator.

xiii. *Smoke Grenades, Generators, etc.*—The smoke grenade is obsolescent. Smoke generators are at present issued only for training purposes.

Smoke will almost certainly play a most important part. In defence it may be used to blind the enemy covering fire and mystify the attacking troops, incidentally making them good silhouette targets. In attack it may similarly be used to blind enemy fire, but better surprise is often achieved if a side is attacked different from that which has been blinded. In the assault, smoke inside a house can be overwhelming.

2. Equipment

i. *Shoes.*—When obtainable, rubber-soled shoes are in every way preferable to Army boots, combining the advantages of silence and a good grip.

ii. *Respirators and Gas-Capes.*—Respirators may be needed against S.I.P. grenades, dust, etc., and should always be carried. If orders permit, gas-capes may be discarded in built-up areas, where there is so much cover from spray attack.

iii. *Haversack.*—There are, in street fighting, features which make the wearing of the haversack by advancing or attacking troops not only undesirable but unnecessary. The contents of the pack are:

(*a*) Knife, fork, spoon and mess-tin.
(*b*) Spare pair of socks.
(*c*) Groundsheet.
(*d*) Food.

Shelter is provided by houses, where sufficient utensils and underclothes can also be commandeered. Though food may also be found, some must certainly be taken and may be carried in a pouch or pocket.

iv. *Periscopes.*—Periscopes are invaluable for officers and N.C.Os. and for the point section of each attacking platoon. The present issue should be supplemented by home-made productions.

v. *Ladders.*—Short ladders are often useful in the attack, and one per company may be carried. They can often be commandeered on the spot.

CHAPTER VI

TRAINING

General

Training should follow the sequence:

Lecture.
Demonstration.

1. Lecture

i. A lecture is made more vivid if accompanied by blackboard diagrams or a street sand table (see below).

ii. Tabulate the lecture and help the audience to take notes by showing what your headings are.

iii. Watch your audience to allow them time to take down notes.

iv. Do not read your lecture. You must be vivid, animated, and get your lecture "across."

v. Above all, keep *still* while you are talking. It is impossible to follow a shuttlecock for an hour.

2. Demonstration

N.B.—The following paragraph may frighten some readers off demonstrations for good and all. Precisely the opposite effect is hoped for. There is no form of training so vivid or effective as a well-prepared demonstration. While it is idle to pretend that a good demonstration will not take time and trouble, there are many refinements mentioned here, *e.g.*, the Tannoy loud-speaker, which can be dispensed with for all normal occasions. (An excellent street-fighting demonstration can be given after six hours' preparation.)

The demonstration should follow the lecture as soon as possible.

i. PREPARATION OF THE DEMONSTRATION.

(*a*) Select the date and time and the performers. Make sure that they are clear for the hours of rehearsal. Have about four spare men attending the whole preparation, to fill the places of men who go sick, etc.

(*b*) Work out *on paper* a detailed syllabus of the demonstration. This must be related to the ground, to the men who are performing, and to the audience.

Every confusion or gap in the thought of the instructor will be multiplied by the number of men taking part and lead to untold delay and avoidable inefficiency.

(*c*) Walk the performers round the area, and describe to them generally what is to happen and where each section of the demonstration is to take place.

(*d*) On the blackboard, or with toy houses, make a plan of the area and go through with your men the sequence of the demonstration. As you come to each stage, make the platoon sergeant detail off the men who are affected, and make them stand up. Explain in detail what is wanted, and tell them the points which it is desired shall be brought out. Answer questions.

(*e*) When everybody is quite clear in his mind, and not before, take the men out on the ground and rehearse them through the demonstration itself.

(*f*) When preparing the demonstration, always consider the position of the audience. The best demonstration in the world is valueless if the audience cannot see it properly. The problem becomes acute in a demonstration of the preparation of a house for defence.

(*g*) With more than one instructor it is possible to divide the demonstration up into sections with a separate instructor, a separate sub-area, and a separate sub-unit. If this is done, much time can be saved, but it is quite essential to rehearse the whole demonstration through at the end until it falls together.

(*h*) Above all, it is vital that there shall be one O.C. demonstration, whose word is law.

(*i*) For expert advice as to shoring, clearing floors, building construction, etc., the O.C. demonstration should ring up the local Home Guard, who are sure to have a carpenter and master builder willing to help. Failing that, the local surveyor will be able to suggest somebody.

Arson by Electronics

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Arson by Electronics

INTRODUCTION:

The electronics industry in general has enjoyed a phenomenal growth within the past score of years, a growth that has continued on an accelerating scale especially during the preceeding decade. Expansion of the industry will certainly go on toward limitations that cannot be foreseen, as the art of electronics becomes incorporated more and more into our everyday scheme of living.

In the State of Florida, the development of such activities has been, and continues to be of great economic importance. Measured by employment alone, electronics in Florida increased by a factor of ten between the years 1953 and 1961. In fact, in 1961, the electronics firms in this state employed well over 12,000 persons. And these figures alone do not reflect the true increase in size of the industry itself and industries possessing a close relationship. Herein we refer to aircraft, missiles, scientific instruments and nucleonics.

Numerous groups are engaged in the production of electronic devices, and many others are producing electronic and other precision components for various Florida manufacturers. Research is being carried on by many of these companies, either as their sole activity, or as an additional activity. Electronic items now being produced in quantity in Florida include, but are not limited to, X-ray tubes, microwave and receiving tubes, printed circuits, transistors, coils, solenoids, resistors, capacitors, transformers, relays, regulators, timing devices, commutators, communications equipment, computers, and radar guidance and control systems.

The greatest concentration of these businesses may be found in the Miami area, Orlando, Patrick Air Force Base, Port Canaveral, St. Petersburg, Clearwater, Tampa, West Palm Beach, Cocoa Beach, Eglin Air Force Base, and Fort Lauderdale, but smaller groups and individuals are scattered from one end of the state to the other.

From the standpoint of the economic welfare of Florida, all of the considerations are on the good side of the ledger, but at the same time, these facts pose a potential problem to the law enforcement agencies; a problem that is real and also rather frightening.

We are speaking, of course, of the possibility that the personnel and techniques now employed in these precision enterprises may become diverted into criminal paths. To be more specific, the Office of the State Fire Marshal is concerned with the diversion of these capabilities toward the crime of arson and the origination of explosions of a criminal nature. We are doubly at a disadvantage in the State of Florida, since there is great emphasis on research among our electronics people; that is to say, some of the country's best electronic brains are here. This points to the conceivability that we will not be dealing with criminals possessing limited skill, but rather with those of the highest ability. Sir Arthur Conan Doyle once stated that there is no criminal so dangerous as a doctor who has gone wrong, and should a well schooled electronics employee go astray, we should find ourselves in a no less precarious situation.

Therefore, we have prepared this manual against this hypothetical eventuality. There is little or no information available on this subject at the present date, so we approached the problem from the standpoint of an electronics engineer who desires to commit arson or who desires to cause a criminal explosion. These pages attempt to set forth the basic techniques by which such crimes may be committed, try to show come of the fundamental circuitry involved, try to point out the circumstances in which these methods may be utilized, and attempt to show the investigator what to look for as evidence of this type of crime. The writing makes every effort to be as non-technical as possible, so that the reader not familiar with electronics will be able to understand it thoroughly.

It should also be made clear that the methods herein described are definitely not the only methods that may be used. In relation to the manipulations possible through a full use of modern electronics, they are crude and basic. Endless variations as well as combinations of these circuits exist. New materials and components are being developed that may find use in this area. Component miniaturization is leading to compact devices.

This, then, is a "do-it-yourself manual."

At the outset, it is necessary that we delineate between the term "electrical" and the term "electronic." Electrical devices of many types have been with us for years, and have often figured in the commission of crime. Electronic devices, on the other hand, are of comparatively recent origin, and their incidence in the commission of crime is not known.

By "electrical" we mean the phenomena of an induced current of electricity passing through a conductor and producing a useful effect in the form of heat or energy. An example of an electrical device would be the household iron. In this article, useful heat is produced by the passage of a current of electricity through a resistance unit imbedded within the iron itself.

By "electronic" we mean the emission, or the giving off, of electrons from the surface of a material, and the behavior of this emission as in vacuum tubes, photoelectric cells, solid-state devices (transistors, diodes), etc. An example of an electronic gadget would be the photographic exposure meter. Here, the presence of a certain amount of light causes the emission of electrons which, in turn, cause the movement of a pointer along the divisions of the meter face.

In the interest of simplification, we may say that the operation of any electronic device depends in some way upon the emission of electrons; purely electrical devices do not.

Hence, electronic arson is nothing more than arson in the conventional sense, except for the fact that an electronic contrivance has figured in the initiation of the event.

But why should the incipient arsonist or the criminal planning an explosion bother with such an elaborate method? After all, the candle in a pile of shredded paper or the match applied to a powder trail does an efficient job.

The answer is both obvious and quite simple. He will take the extra trouble necessary because electronics can supply him with certain features desirable to his profession that are not available by other methods.

He will be able to set off his "plant" by remote control, thus enabling him to be many miles from the scene of the crime. If he is seen in some distant city at the time established for the crime, his alibi is nearly air-tight. He may push a button by remote control and initiate the disaster at his convenience, or he may provide suitable delay devices that will do the job for him at a predetermined moment or at a random interval that not even he would know. He may arrange for the crime to be triggered by an unwitting outsider.

He knows that the detection of the method used will be difficult. Few law enforcement agencies can have an electronics specialist at their disposal, and detection requires that personnel be thoroughly trained in the recognition of significant clues. He knows that electronic devices are becoming more sophisticated and, as a result, are becoming more compact and therefore more easily destroyed beyond recognition in a fire or an explosion.

Best of all he has a wide choice in the method of procurement of electronic apparatus. He may purchase the parts and build a device from "scratch." He may buy a suitable kit and assemble it himself. He may purchase the desired device ready-made. Whatever his choice, he knows that anyone can buy electronic components or finished units without arousing the slightest suspicion. Aside from the professional people utilizing electronics, each city of any size has hundreds of individual experimenters and tinkerers.

The use of electronics in crime will be most insidious.

This brings us to an important question. Is this method now in use? Is the science of electronics being used to start fires and cause explosions? We have every reason to believe that it is.

During the past several weeks, we have engaged in correspondence with the fire marshals of forty-one states. Many of them corresponded with other law enforcement agencies and national investigators. A few of them flatly stated that they had experienced nothing of this nature. Many others, however, expressed grave concern as to the possibilities raised by the thought of such crimes. Still others went so far as to say that they may have encountered electronic devices in this context but were not able to prove it.

The State of Florida happens to fall into this latter catagory at this time. At least two fires of suspicious origin were recently investigated by this office. Indications are that at least one of them and possibly both of them were triggered by electronic means.

One state contacted has been most fortunate in this respect. They managed to catch a potential electronic arsonist red-handed. He was a professional electronics man, and was able to devise a seemingly fool proof scheme. Flammable materials were placed in close juxtaposition to an electronic device consisting of a battery operated radio receiver, an initiating relay connected to the receiver, and a heating coil attached to and activated by the relay.

Theoretically, a pulse was to be sent from a radio transmitter located at some distance from the "plant." The receiver was to pick up this brief pulse and, in turn, the relay was to close, thus introducing electricity into the heating element. This was intended to ignite the flammable material. Many little niceties were included in the plan. All interconnection of the various components was carried out with solder having a low melting point. It was expected, of course, that the solder would melt and dissipate in the ensuing fire and all evidence of arson would, therefore, be destroyed. Unfortunately, there's many a slip between cup and electronics. The "plant" went off according to plan, but the fire was discovered before any severe damage had been done and, more important, before the electronic device used in starting the fire had been destroyed.

All of this seems to indicate that electronics will become one of the modern day tools of arson. Concern should not be manifest over the probability that its use is not particularly wide spread at this moment. It appears certain that if electronics has not already been utilized by a large segment of the criminal element, it soon will be.

II. WHAT ELECTRONIC ARSON HAS IN COMMON WITH CONVENTIONAL ARSON:

New science and technology develop, and new faces indulge themselves in illicit pursuits, but certain fundamental ideas tend to remain constant.

We may expect the basis or the reason for arson by electronics to be much the same as for arson as we now know it.

The desire for economic gain may provide the impetus necessary to cause a person to commit this criminal act. Many ramifications of this single rationale may exist. The gain therefrom may accrue directly, or the gain realized may be so far removed from and seemingly unrelated to the act itself that discovery or proof of the relationship becomes next to impossible.

The grounds for arson may possess no intrinsic validity in its own right, but may be engendered by or be the outgrowth of another offence. The embezzler may choose this method as a handy means of concealing his crime. The murderer finds it expedient that the results of his handiwork should disappear without trace, or at least should appear to have met with misfortune by another agency. The dishonest merchant who has been falsifying records of his assets takes the chance in order to prevent disclosure.

Arson for personal satisfaction may run the whole gamut of human emotions and their many nuances. The disgruntled employee may seek to secure some form of gratification by causing inconvenience or even complete ruin to his employer. Already hardened criminals may find it convenient as a method of beating recalcitrant victims into line. The would-be politico or labor organizer might discover through arson an outlet for his revenge.

Or the arsonist may be a "nut"; i.e., a mental deviate. He may achieve sexual enjoyment from the starting of a fire or from watching the ensuing conflagration and its attendant excitement.He may possess feelings of general hostility or inadequacy which find their outlet in the perpetration of a fire or an explosion. And, in this category, we may find something new. The ancient Romans had a saying, "Ars Gratia Artis," which in modern times, might be paraphrased into the concept of Technology for the sake of Technology. The electronics specialist is a scientist, a mathematician, a man with an excellent knowledge of applied physics. But he is more than this in some instances. He may be an artist in his own right. It seems feasible that such a man, assuming him to have a sufficient mental aberration, might simply like to see his plan work. This could be one of the most dangerous kinds of electronic arson, since the design could be expected to be most abstruse and elaborate.

We may expect to encounter the use of the same materials in the initiation of such fires and explosions as are found by present investigations. The arsonist needs something that is readily flammable or explosive, and most of the materials that have been in use during years past will still provide the desired result. The man with a knowledge of chemistry, however, may wish to branch out a bit in his choice. Pyroxylin plastic, for example, being of such a chemical composition that external oxygen is not necessary to its combustion or decomposition would furnish the fire service with some anxious minutes in the early stages of the blaze. It could not be extinguished by smothering and would, therefore, be difficult to combat without large quantities of cooling liquid. Ammonium nitrate would offer the same hazard. It is easily obtained, carries its own oxygen supply within itself, and gives the arsonist the additional dividend of producing copious quantities of extremely toxic fumes.

Whatever the choice of the material, its general type will be common both to electronic arson and conventional arson.

The circumstances surrounding the actual commission of the crime will supply the final area of correlation between the two types of arson. The circumstances may be identical in both cases, but because of the peculiar advantages offered by electronics, certain associated facts may not be so clear-cut or have such an obvious relationship to the crime. We may expect the relevancy of the integral facts to the crime to be quite abstract in some cases..

But, sic transit gloria obsolescent arsonist. Electronics has new things to offer.

III. HOW ELECTRONIC ARSON IS DIFFERENT FROM CONVENTIONAL ARSON:

Electronic arson is characterized by certain distinguishing features that set it apart from ordinary arson, and it is these factors that will tend to make it so attractive a method to the lawless element.

The foremost difference, of course, is the manner of triggering the fire or the explosion. This may be as simple or as complex as the individual circumstance may warrant, but the actual triggering will, in all cases, be accomplished by electronic means.

At the less exotic end of the scale we have the straightforward timing devices. These may be electro-mechanical in nature, or may be strictly electronic. They may be an integral part of an existing household appliance. They may be self-contained units, rather bulky by comparison. They may take the form of a tiny, hand-built electronic circuit hidden away in some inconspicuous spot, and prone to destruction by an ensuing holocaust.

At the other end of the scale, in degree of complexity, stand the radio-controlled devices. These may be rather small and unembellished if designed to operate at close range, but may become quite large and somewhat ornate if designed to produce consistent results over a long distance. Equipment associated with the radio paraphernalia will be determined by the ultimate job the mechanism is to accomplish. For example, an unadorned radio system might use a single pulse to initiate an entire fire or explosion. With more supplemental components, a sequential system may set multiple fires or detonate multiple explosions on each subsequent command.

Between these two extremes are encompassed a Pandora's Box of myriad contrivances such as counters, light-controlled switches, moisture sensors, heat and cold sensors, capacitively operated relays, and uncountable combinations of all of these and many more.

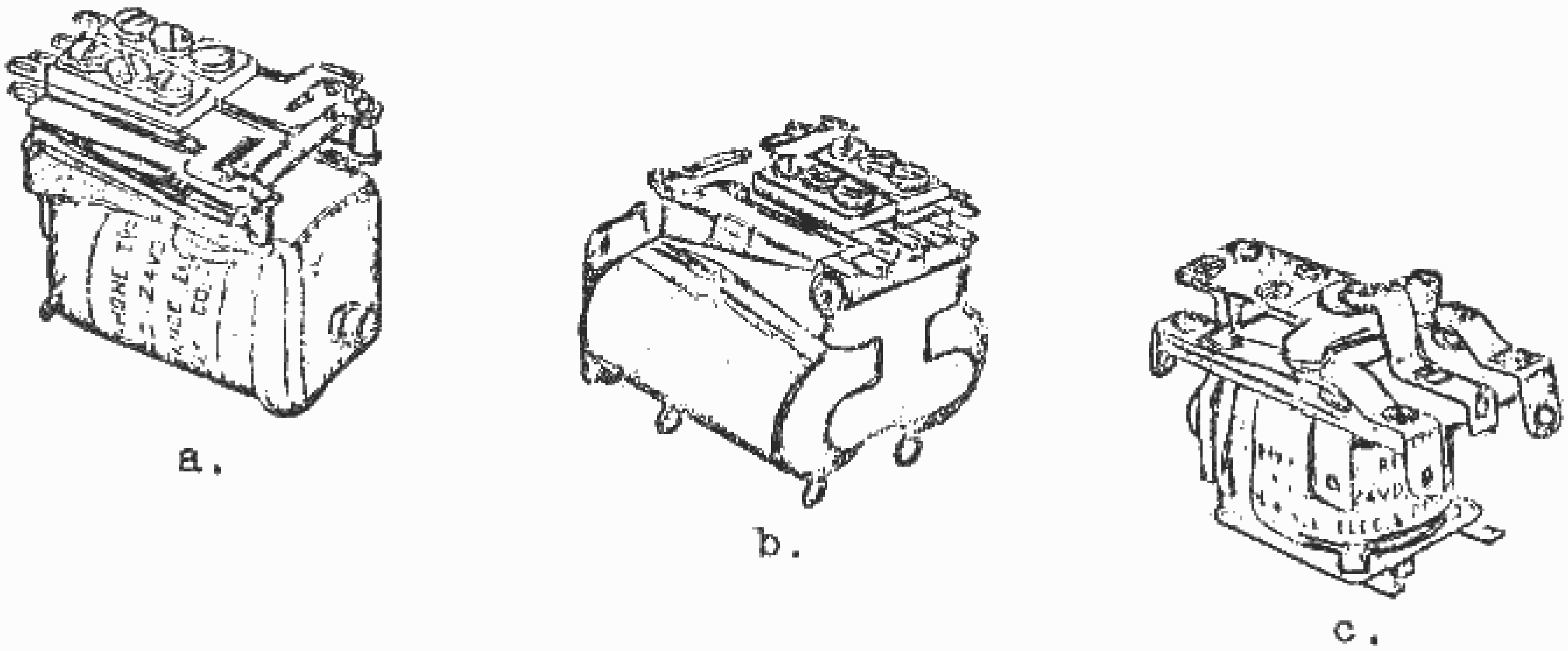
The devisor's imagination is quite free to soar to whatever heights of malevolence that he would like to reach. We are reminded of the condition existing during and immediately following World War II, when rugged groups of men were laboring to disarm unexploded bombs that had fallen in populous areas. They succeeded in developing proficient disarming techniques, only to discover that the enemy had devised even more cunning and elaborate trigger systems to prevent easy neutralization. In a like manner, variation in the assembly of these electronic gadgets will permit modification ad infinitum, and this will make detection progressively more difficult.

It is most obvious that arson by electronics will be marked by seemingly mixed-up time and space relationships. The principal suspect may be discovered to be at a great distance from the scene of the crime. Polygraph examination may show that the accused has no actual knowledge as to when the alleged crime occurred. The suspect may be in the company of friends at the time the incident takes place. He may be enroute to some distant point. He may have been absent from the locale for a number of days prior to the crime. The fire or explosion may take place during the day in the presence of witnesses; it may happen when the site is uninhabited. All of these situations, and many others, become valid propositions when electronics is utilized. It is also certain that the mere establishment of the corpus delicti will be exceedingly difficult when such means are employed.

Arson by electronics may be presumed to be of an inherently more elaborate nature than conventional arson. It also follows that the criminal himself may be expected to be of a more intelligent and more highly educated type. It is true that a portion of the people employed by the electronics industry are purely theoreticians and therefore do not necessarily possess the practical ability to implement such plans, but many of them are craftsmen, not only in electronics, but in allied arts such as chemistry, physics, and machine tool practices. In these cases it would be unnecessary for them to acquire outside help, thus restricting intimate knowledge of the offense to a minimum number of persons.

One item of equipment peculiar to arson or explosion by electronics may be expected to be found in common with all such crimes. We refer to the relay. The relay is actually nothing more than an electrically operated switch, by means of which a relatively large amount of voltage or current may be controlled by a very small amount. It consists of two fundamental parts; the actuating coil or solenoid that moves the contact section built into the unit, and the contact arrangement itself whose function is to either break or complete an external circuit. The relay is available in any number of shapes, sizes and current handling capacities, and in a great variety of assorted contact and coil configurations. It is low in cost, and can be secured from thousands of sources. Its general appearance is something like this. (Fig. 1)

In the case of most electronic components, it would be too clumsy a procedure to draw a pictorial representation of a part every time it was desired to show the use of the part in a circuit. Instead, a schematic equivalent or symbol of the component is used.

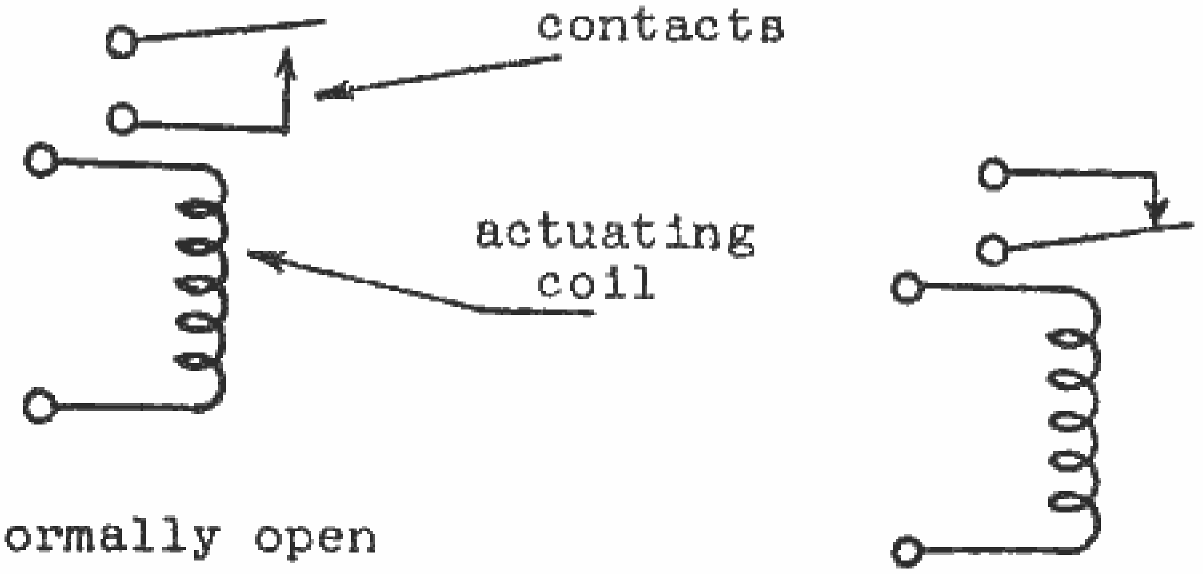


a.

b.

c.

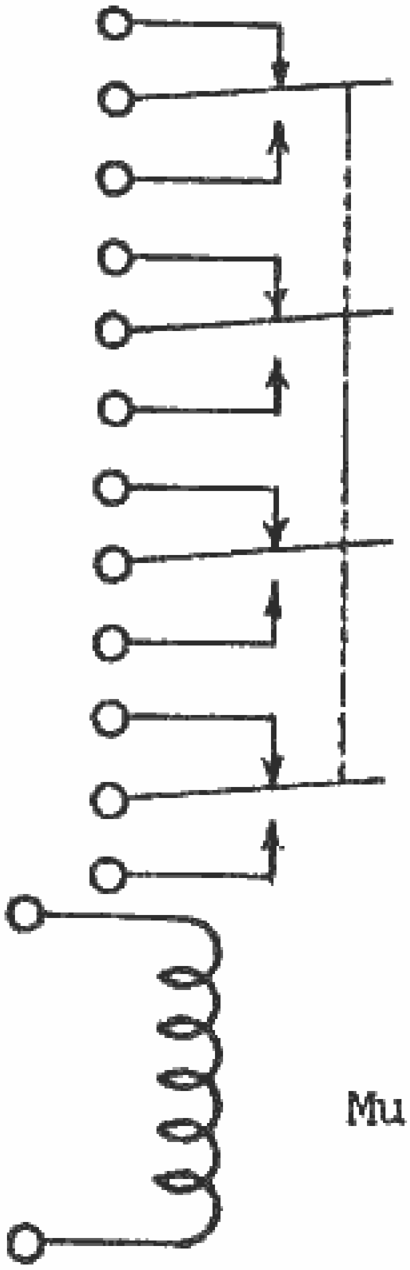
Figure 1.


contacts
actuating coil

a. normally open

b. normally closed

Figure 2.



All armatures (parts connected with dotted line) move at the same time.

Multiple contact relay

Figure 3.

Regardless of the type of relay, two basic contact arrangements are commonly found, and are depicted schematically like this. (Fig. 2)

Operation of the device is easy to understand. A pulse of electricity is sent through the actuating coil, causing it to become an electromagnet. This action pulls the contact assembly toward the pole piece of the electromagnet, and thus closing the points as in figure 2b. By this means the external circuitry is either completed or broken.

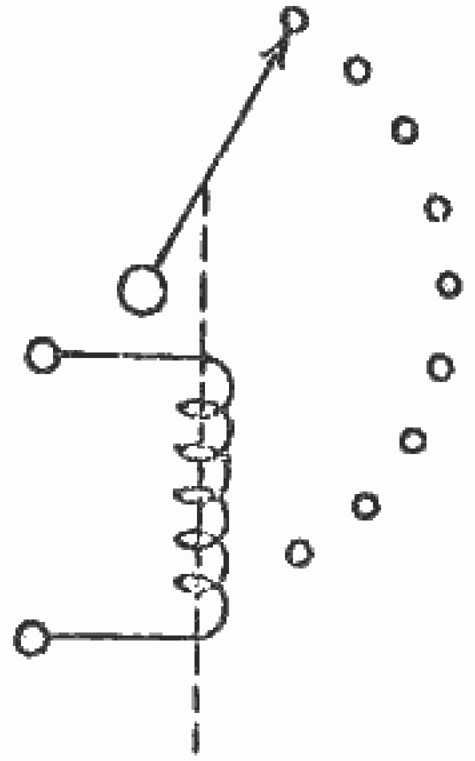
Relays incorporating rather bizarre contact formations, such as the multiple contact relay, may be secured. This unit makes possible the simultaneous activation of several circuits. (Fig. 3)

Sequential or stepper relays are also quite common. Every time an individual pulse of electricity reaches this type of relay, successive external circuits are operated. (Fig. 4)

Following a fire or an explosion in which the use of an electronic device is suspected, it is quite possible that the remains of a relay will be present in the debris near the point of origin of the event. Several different types of rare metals are often used in the production of relays, and some of these materials possess a high melting point.

The actuating coil of the relay, although usually wound with small copper wire, is not easy to destroy. It presents a somewhat dense mass, being made up of a great number of turns of wire, and is usually provided with a solid iron or steel center or core.

Following, is a list of some of the relay parts that might be recovered after an incident, together with a list of the materials from which these parts are commonly made, and the melting point of each substance.



Contacts advance one position only with each activation of the coil.

Sequential or stepper relay

Figure 4.

Actuating coil - - - - - - - - usually wound on some kind of phenolic bobbin or form with iron or steel center. Winding of copper wire, most often insulated with enamel.

Melting points

Copper - - - 1981 degrees Fahrenheit

Iron & Steel - - - 2200 to 2800 degrees Fahrenheit

Contact points - - - - - - - - often made of silver, gold-flashed silver, platinum, palladium.

Melting points

Silver - - - 1700 to 1800 degrees Fahrenheit

Gold - - - 1950 degrees Fahrenheit

Platinum - - - 3223 degrees Fahrenheit

Palladium - - -2882 degrees Fahrenheit

Contact arms - - - armature hinges - - - usually of brass or beryllium copper.

Melting points

Brass - - - 1700 degrees Fahrenheit

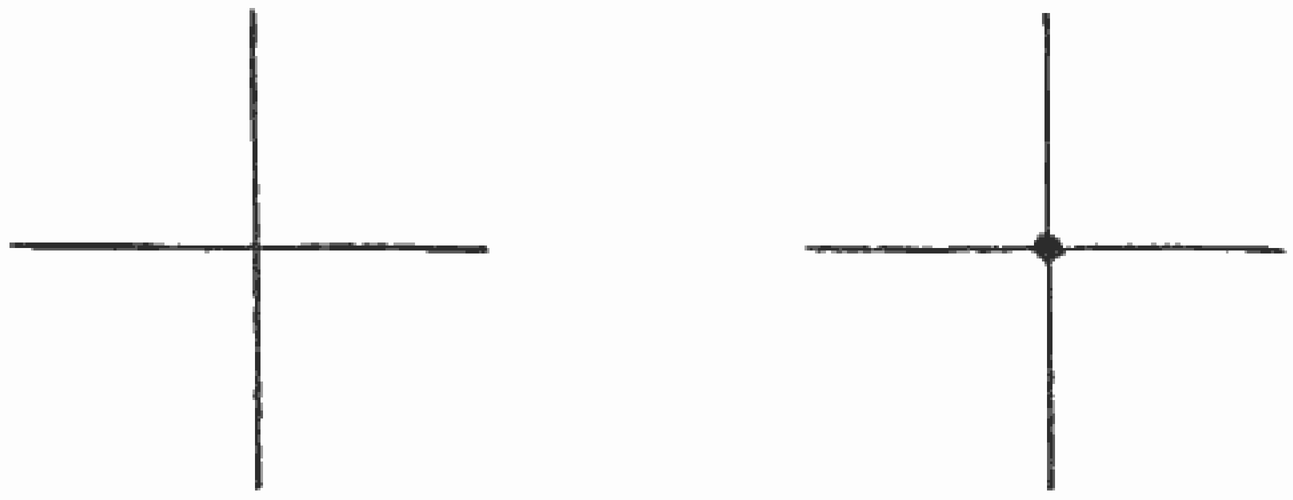
Beryllium - - - 2343 degrees Fahrenheit

Consideration should be given to the fact that these materials will not instantaneously achieve a melted state upon exposure to the indicated temperature; the time required for melting will be a function of the amount of the material present and its particular physical shape.

Just as a symbolic representation of the relay has become the accepted method of depicting that component in an electronic circuit, so have similar figures been adopted as the means of showing other parts. It is not intended that this manual should go into electronic theory, but it seems advisable that the reader should be conversant with some of the fundamental notations used in the basic hook-ups. Here then, is a list of the more common electronic components; their schematic equivalent, and their actual appearance. No attempt has been made to show these articles in any relation to their true size. Many of them are made and used in sizes ranging from extremely small to very large. Those interested in the precise function of these parts and their associated circuitry are referred to any standard text on the subject such as the RADIO AMATEUR'S HANDBOOK. (Fig. 5)

IV. INITIATING MEDIA AND INITIATORS:

In the perpetration of any arson, it is necessary that some flammable material be abundantly available. This is equally true of the origination of a criminal explosion for actually, there is no clear-cut line of demarcation between fire and explosion. The only differentiation is as to rate of burning; i.e., rate of oxidation. According to the accepted understanding of the term "burning," ordinary flammable substances enter into combination with oxygen at a fairly rapid rate. When this rate becomes fast enough, the materials are referred to as "low" or "deflagrating" explosives. Finally, the rate increases to the point where the usual terminology is no longer applicable, and the expression "detonation" applies. In some situations, such as the burning of gasoline vapor, it is most difficult to categorize the incident. Sometimes the phenomenon is termed "explosion"; sometimes "flash-fire"; at other times, just plain "fire." In any case, the fundamental chemical reactions are identical except as to rate.



a. wires crossing but not connected

b. wires crossing but connected

Figure 5.

If the destruction of a specific building is desired, some initiating medium must be employed. One of the tribulations associated with the arsonist's life is the fact that certain materials can be disgustingly difficult to ignite. He cannot simply apply a match to the leg of a chair and expect it to burn. Most

Figure 5. c.

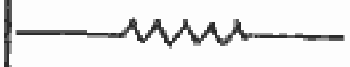
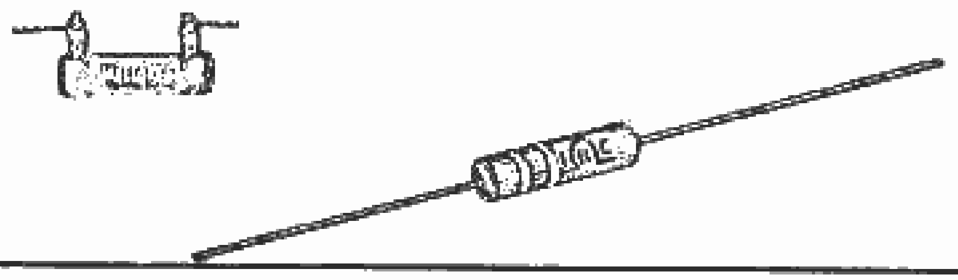
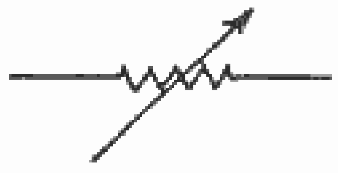
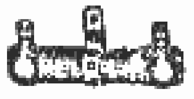
Component	Schematic Symbol	Actual Appearance
Fixed resistor		
Variable resistor		

Figure 5. c.

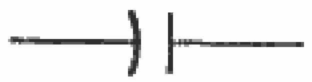
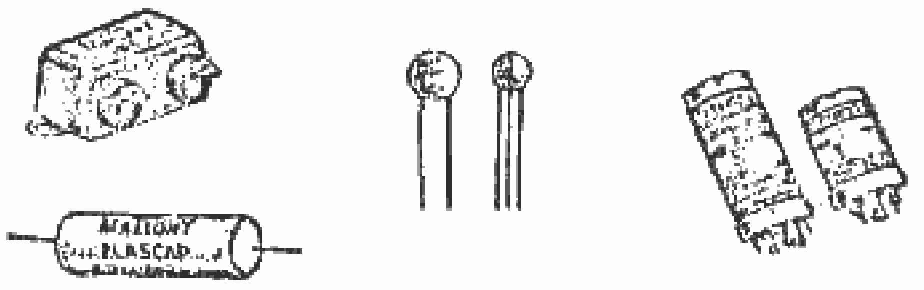
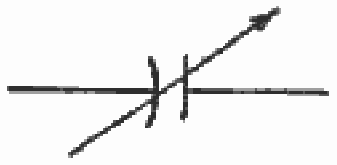
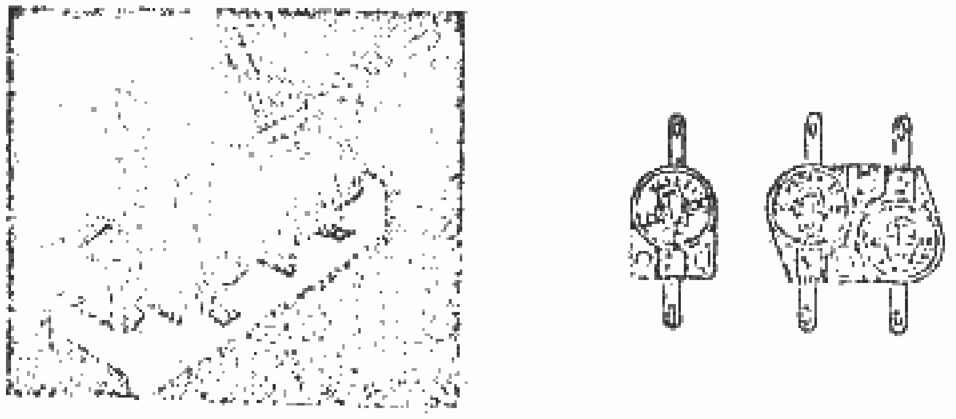
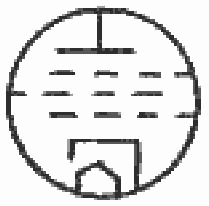
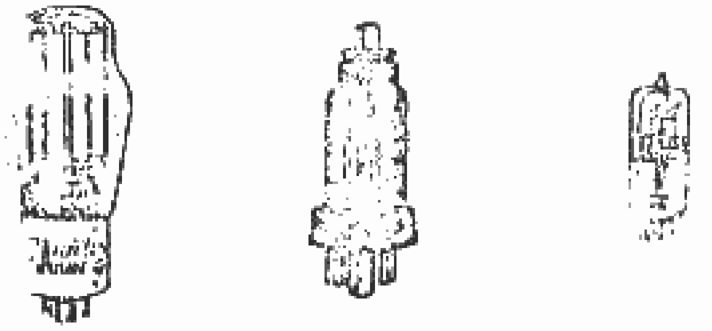
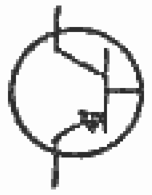
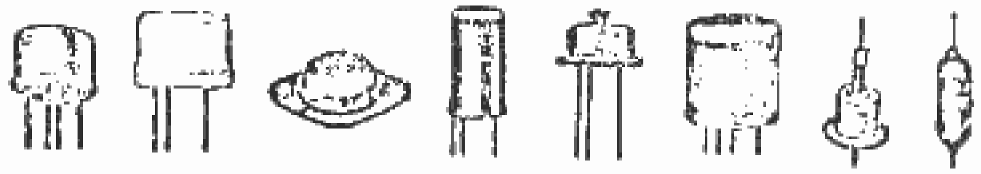
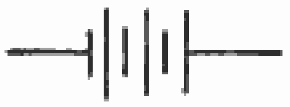
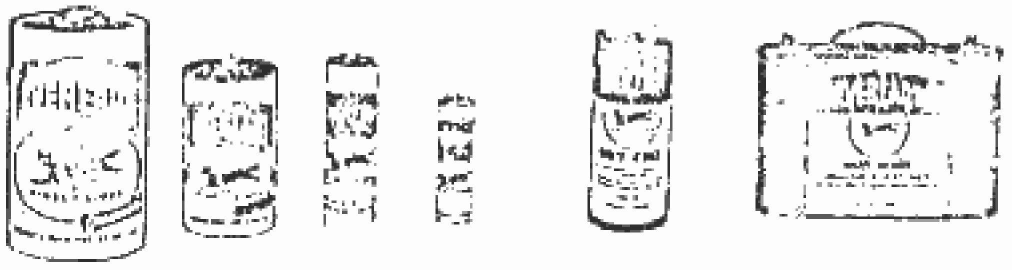
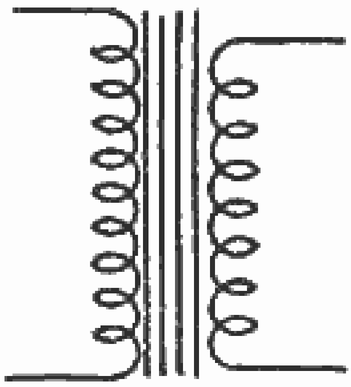
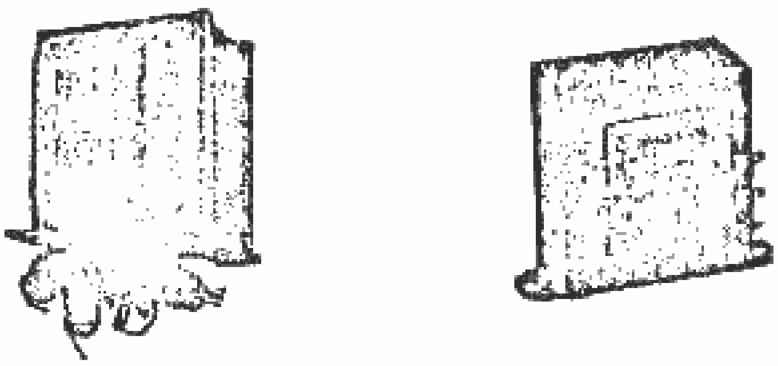
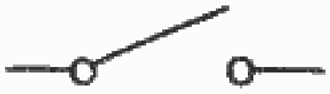
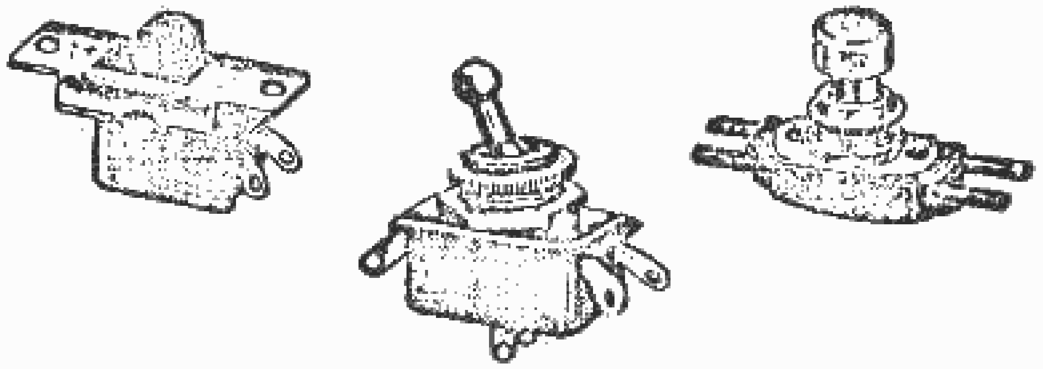
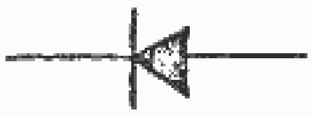
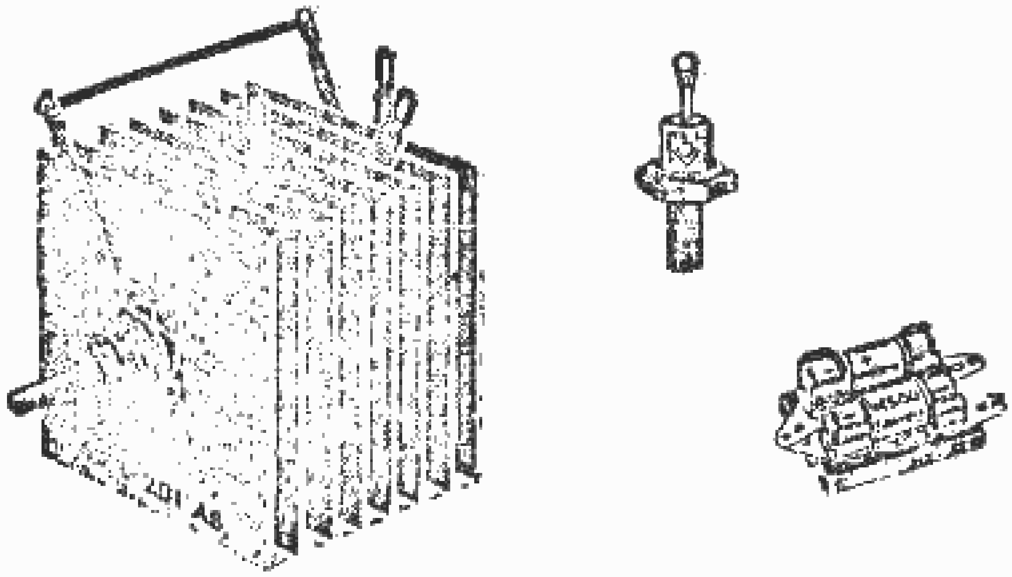
Component	Schematic Symbol	Actual appearance
Fixed capacitor		
Variable capacitor		
Vacuum tube		
Transistor		
Battery		
Transformer		

Figure 5. c.

Component	Schematic Symbol	Actual appearance
Switch		
Rectifier		

woods will withstand a temperature of approximately 750 degrees Fahrenheit for a period of 20 to 30 seconds before igniting.

In addition, several other factors must be taken into consideration. In the burning of most substances, actual combustion takes place only after the solid or liquid fuel has been decomposed or vaporized sufficiently by heat to form a flammable gas. Ignition occurs only when there is present a favorable combination of suitably high temperature and a large enough quantity of heat to initiate self-sustained combustion.

A fire can be self-sustaining only where there is fuel, an oxidizing agent, and a temperature that remains high enough to maintain combustion. The match flame is very hot (about 2000 degrees Fahrenheit) and should, therefore, be capable of igniting the chair leg. This level of heat, however, cannot be sustained; the adjacent wood conducts much of the residual heat away from the point of origin, and combustion does not occur. It soon becomes apparent that some substance more readily flammable must be utilized to start such a blaze.

The ignition temperature of ordinary combustible materials, or the minimum temperature required to cause self-sustained combustion independent of the external heating agent, lies between 300 and 1,000 degrees Fahrenheit. Furthermore, the actual ignition temperature of a given material varies considerably with the physical form of the material. Usually, the smaller the particles of the substance, the lower the ignition temperature. Shredded or cut paper will ignite more readily than tightly rolled or tightly bound newsprint. The vapor of a combustible liquid, being in individual molecular form, will ignite more quickly than a tub full of the material. A fine cloud of combustible dust will ignite quite easily with a comparatively small amount of heat from a mechanical or an electrical spark.

Certain other rather stringent limitations are attached to flammable solids and liquids as to the precise conditions under which they will burn or explode. The explosive or flammable limits of a material refers to the ratio between the amount of potentially flammable vapor in mixture with ambient air or oxygen. The lower limits are defined as the minimum concentration of vapor in air or oxygen below which the propagation of flame does not occur on contact with a source of ignition. Likewise, there is a maximum concentration *above* which ignition does not occur. As may be expected, these limits have wide variation dependent upon the particular material involved.

Where a flammable liquid is used, the flashpoint of the substance is an important factor. This is the temperature to which the liquid must be heated so that it gives off sufficient vapor to form an ignitible mixture with the air near its surface. The fire-point, normally a few degrees higher, is the temperature at which the vapors are evolved fast enough to support continuous combustion.

From the standpoint of a purely chemical reaction, all or most of these criteria must be fulfilled before an active blaze can begin and continue. An arsonist's life is not a completely happy one.

Therefore, before he can commit a crime of this type, he must provide an initiating medium that will ignite quickly and reliably at a rather low temperature. Upon ignition, it must progress rapidly to a reasonably high temperature, and it must sustain that temperture peak until the ignition of surrounding material takes place. If he can arrange for this medium to disappear following combusiton, so much the better.

Herewith is a list of some materials that fulfill most of these parameters, together with the approximate ignition temperatures of each substance, their flammable and explosive limits, and pertinent data peculiar to each material.

---

1. Shredded materials:
   a. cut newspaper - - - ignition temperature 446 degrees F.
   b. cut filter paper - - - ignition temperature 450 degrees F.
   c. excelsior- - -
   d. straw - - - - - - - - ignition temperature 450 to 500
   e. sawdust - - - degrees F.

   All of these materials should be placed in a rather loose mass in order to permit free access of oxygen to the material.
2. Liquid Hydrocarbon Fuels:
   a. gasoline - - - - - ignition temperature 536 to 800 degrees F. depending on the octane rating

      flash point minus 45 degrees F.

      explosive limits: (percentage of vapor in air by volume):

      upper limits 7.6%
      lower limits 1.4%

b. kerosene - - - - - ignition temperature 480 degrees F.
(No. 1 fuel oil)

flash point 100 degrees F.

explosive limits (percentage of vapor in air by volume):

upper limits 5%
lower limits 0.7%

3. Gaseous Hydrocarbon Fuels:

a. natural gas - - - - - ignition temperature 1,000 to 1,200 degrees F.

explosive limits (percentage of vapor in air by volume):

upper limits 15.0%
lower limits 4.5%

b. LP gases - - - - -

1. propane - - - ignition temperature 871 degrees F.

explosive limits (percentage of vapor in air by volume):

upper limits 9.5%
lower limits 2.2%

2. butane - - - ignition temperature 806 degrees F.

explosive limits (percentage of vapor in air by volume):

upper limits 8.5%
lower limits 1.9%

Strictly speaking, propane and butane might well be classified as liquid fuels, since they are normally stored as liquids under pressure, but utilized as gases.

4. Paints and Lacquers:

Ignition temperature may be anywhere from 475 to 1,000 degrees F.

Flash-point usually 80 degrees F. or lower.

The flammable part of these materials is not the pigment, although certain metallic chromate pigments are, in themselves, flammable.

Combustion takes place in the oils, solvents, vehicles and thinners. Some of these, depending on the type of paint or lacquer are:

Amyl Acetate - - - - - - - - - - - - ignition temperature 715 degrees F.

Acetone	ignition temperature 1,000 degrees F.
Linseed Oil	ignition temperature 650 degrees F.
Mineral Spirits	ignition temperature 473 degrees F.
Petroleum naptha	ignition temperature 475 degrees F.
Alcohols	ignition temperature 750 to 900 degrees F.
Turpentine	ignition temperature 464 degrees F.

5. Alkali Earths and Metals:

a. Magnesium - - - ignition temperature 1,204 degrees F. but may be as low as 900 degrees F. if the material is in finely divided powder form.

Cannot be extinguished with water or CO_2. The oxygen in both of these materials feeds the reaction and the fire becomes more intense. Suppression of the blaze can be accomplished only with large quantities of dry sand, dry NaCl, or dry soda ash. Magnesium is easily obtainable, but may be extracted from certain photographic flash-bulbs to avoid detection.

b. Sodium - - - provides a reaction with water.
Also reacts violently with inorganic acids. Its reactive process is:

$$2Na + 2H_2O = 2NaOH + H_2$$

c. Potassium - - - undergoes the same reaction, only more violently than sodium. Its process is:

$$2K + 2H_2O = 2KOH + H_2$$

6. Explosives:

a. Black Powder - - - would not be used as an explosive in this application, but as a connecting link to ignite several initiatory sources. Ignites within the same temperature range as the afformentioned substances.

- b. Primacord - - - a detonating fuse with a PETN core. Decomposes at a rate of 21,000 feet per second. May be used to ignite many initiatory sources simulataneously.
- c. Explosives - - - choice of type will vary with the result intended. High detonation speed will give a shattering or a cutting action; low speed will result in a heaving action.
  1. Gelatin dynamites - - - detonation speeds up to 22,300 feet per second
  2. Straight dynamites - - - detonation speeds up to 18,200 feet per second
  3. Blasting dynamites - - - detonation speeds up to 3,900 feet per second
  4. Nitro-carbo-nitrate - - - ammonium nitrate-fuel oil mixture. Produces a heaving action, but is the most easily obtained without attracting attention. Also burns readily in natural state, being composed of 60% oxygen. Because of this feature, cannot be extinguished by smothering.

After the initiating medium has been placed at the point where the fire or the explosion is to take place, an initiator must be introduced. This is a device whose function is to set the material ablaze or to institute the explosion. One criteria required of all such initiators in electronic arson is that it must be possible to operate the unit electrically. Manual operation under such conditions is neither practical nor desirable.

The devices that could be used as initiators are myriad, but the following list mentions only those that are commonly available, and especially those that can be obtained without attracting undue suspicion.

1. Calrod-type electrical heating units: These are found on most modern electric ranges, are the usual type of heating element in household ovens, and are sometimes utilized in small electric hot-plates. They will provide heat at their surface well in excess of 1,000 degrees F. when they are operated to their full capabilities. These units are often supplied with a calibrated temperature control switch, but the surface temperature can be approximated by observation of the color of the unit.

Table of Heat Colors

Yellow	450 degrees F.
Brown to Purple	550 degrees F.
Blue	600 degrees F.

Faint Red	900 degrees F.
Dark Cherry	1,100 degrees F.
Full Cherry	1,400 degrees F.
Salmon	1,600 degrees F.
Lemon	1,800 degrees F.
White	2,200 degrees F.
Sparkling White	2,400 degrees F.

2. Nichrome wire:
   Wire of this variety is, in actuality, an electrical resistance. When a current of electricity is passed through a length of the wire, heat is produced. Most nichrome wire, like the more modern calrod-type units, will produce surface temperatures in excess of 1,000 degrees F. Nichrome wire may be purchased in almost any length desired or if secrecy is important, it may be removed from small heaters and toasters. It is also often found in the cheaper hot-plates, being embedded in a moulded refractory plate.
3. Household fuses:
   Ordinary protective fuses of the screw-in type can be made to serve as an efficient initiator for black powder. The end window of the fuse is first removed, exposing the fusible link. The altered fuse is then wired directly across a circuit into which 115 volt alternating current can be introduced. Black powder is piled on the fuse, making certain that some gets in direct contact with the interior link. When the circuit is closed, the fuse forms a short circuit to the current path. The fusible link then ruptures with a flash quite sufficient to ignite the powder.
4. Photographic flash bulbs:
   Besides serving as a source for initiatory media, the photographic flash bulb also makes a good initiator for powder trails. The bulb chosen must be of the type filled with magnesium. Certain flash bulbs are filled with aluminum foil and are then charged with oxygen. The latter cannot be used as the aluminum will not produce a flash of adequate magnitude once the oxygen has been liberated. The glass bulb is carefully broken away, leaving the fusible element and its accompanying magnesium charge exposed and undisturbed. The element and its magnesium fuel are inserted in a pile of powder. When a current of electricity is passed through the remains of the bulb, a violent flash will ensue, igniting the powder.
5. Electric squibs:
   Normally used for the ignition of powder charges in blasting operations, the electric squib (not to be confused with an electric blasting cap) is ideal for the initiation of powder, flammable liquids or explosive vapors. Physically, the squib is an aluminum tube of small diameter and about 7/8 of an inch long. A charge of deflagrating mixture is enclosed within the tube together with an electrically fired ignition charge. When an electrical current is applied to the wires embedded in the ignition mixture, the compound flashes, the aluminum shell ruptures, and an intense flame bursts forth. Only a small amount of current, in the order of 1/4 ampere, is required to fire the squib.
6. Electric blasting caps:
   The No. 6 electric blasting cap is the one most commonly used industrially. It is similar to the electric squib, except that its ultimate object is detonation and not deflagration. In form, it is slightly longer than the squib, about 1 3/8 inch, but contains a high explo-

sive base load such as tetryl, a pressed primer load of lead azide, and a loose ignition charge. Wires are embedded in the ignition charge, and are bridged at their extreme end with a small resistance wire. When current is passed through the wires, the resistance element heats immediately to incandescence and a chain of ignition is begun ending in detonation. The final detonation of the cap is enough to cause detonation in most dynamites and gelatins. Two of these caps taped tightly to the end of a piece of primacord will ensure its sudden and violent decomposition.

7. Electrical sparks:

Either electrical or mechanical sparks can easily cause the ignition of flammable vapors. A relatively small amount of heat is necessary since the compounds involved are in widely dispersed molecular form. Mechanical sparks, although they often generate a heat equal to or above 2,000 degrees F., are not practical for such purposes because of the difficulty in generating them with any semblance of reliability. Electrical sparks, conversely, are readily generated and, depending on the generating voltage and amperage, may reach temperatures of 7,000 degrees F. or higher.

A most efficient spark generator is the rather ancient model "T" spark coil. This unit, originally used in the ignition system of that venerable vehicle, made use of a vibrating tongue to make and break the circuit of an induction coil. When attached to a battery, the unit will create a continuous series of sparks at a potential of better than 12,000 volts. In the operation of the device, there is considerable sparking at the points of the vibrating reed. These may be used, or a conventional spark gap may be attached to the external terminals, thereby producing a longer spark.

An interesting variation of this type of initiator is a specific application of the neon sign transformer. Potentials of 20,000 volts or higher may be obtained from these units. The transformer is rather heavy and bulky and can be used as the support, as well as the voltage supply for a horn gap. This device is often encountered in horror movies, since it makes a somewhat impressive and eerie display, but it will also provide a recurring spark of great intensity. The principle of the horn gap is utilized commerically in providing lightning protection for broadcasting stations and for power transmission.

The horn gap may be quickly constructed with a neon sign transformer and two coat hangers, although bare copper wire of about size 12 will be better adaptable. If the coat hangers are used, the paint should first be removed from their surface with some type of abrasive material. Two lengths of the wire, each about 24 inches long, are bolted to the opposite high voltage terminals of the transformer. The wires are then bent in such a way that they are close together near the ends fastened to the terminals, and so that they slowly diverge toward their extremities. The minimum distance of the wires will have to be determined by trial and error, but it should be small enough so that an arc is struck immediately when the transformer is energized. The angle at which the wires diverge should be gradual.

(Fig. 6).

The action of the horn gap is simple. When household current is applied to the primary windings of the transformer, a high voltage is induced in the secondary winding. Immediately, an arc jumps between the two wires at the point of closest proximity. The arc is maintained, and slowly and steadily rises along the wires. Be-

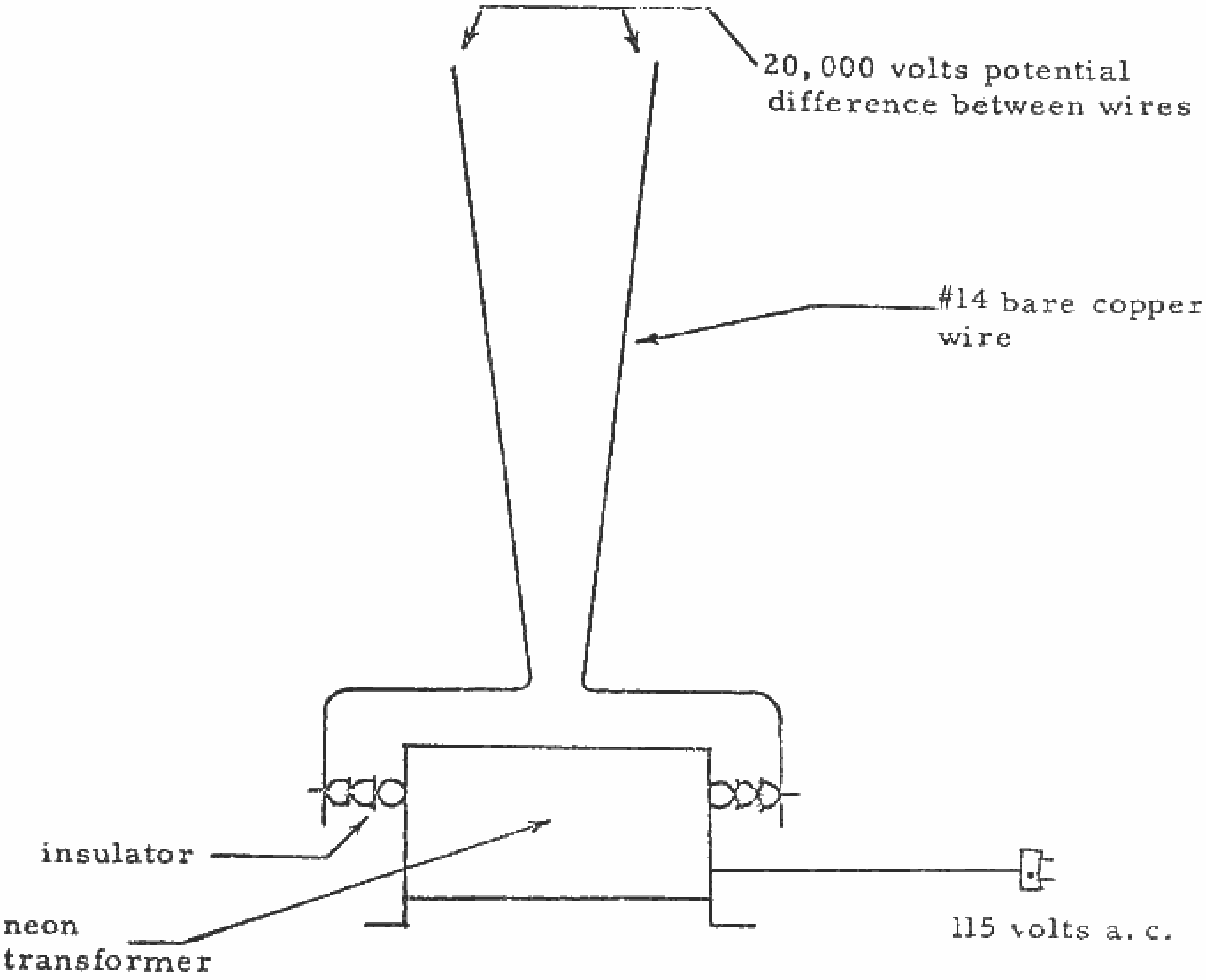

20,000 volts potential difference between wires
#14 bare copper wire
insulator
neon transformer
115 volts a.c.

Figure 6.

Lamp Size	Surface Temperature of Bulb	Filament Temperature
40 to 100 watt	200 degrees F.	4,550 degrees F.
150 to 200 watt	295 degrees F.	4,725 degrees F.
300 to 500 watt	380 degrees F.	4,830 degrees F.
250 watt heat lamp	400 degrees F. or higher	

coming longer as the wires diverge. By the time the arc has neared the top of the gap, the spark is quite long and quite hot, sufficient to ignite almost any flammable or explosive vapor. When the arc finally breaks because the spacing of the wires becomes too great to permit the available voltage to bridge the gap, a new arc forms at the narrow portion of the wires, and the cycle repeats itself.

8. Incandescent bulbs:

Common electric light bulbs serve as excellent initiators for sawdust, some types of thin paper, and powder. Certain conditions must be imposed, however, if they are to prove effective and reliable.

When in operation, the surface temperature achieved by even a bulb of modest size is rather high, and the temperatures reached by the filaments of even a small bulb are astronomical.

If the bulb is left exposed, even though lying on flammable materials, it is not certain that ignition of the material will take place. A red-hot soldering iron will reduce paper to ash without achieving ignition if it is left lying on the paper while it is heating. On the other hand, if the iron is up to maximum temperature before making contact with the paper, ignition will occur at once. This is also true in the case of the exposed bulb, since much of the heat is dissipated into the ambient air.

Even a 25 to 40 watt bulb, if tightly wrapped in several layers of tissue paper or buried in finely divided combustible material will reach a temperature of 800 to 900 degrees F. within 20 to 30 minutes. A larger bulb will accomplish this amount of heat more

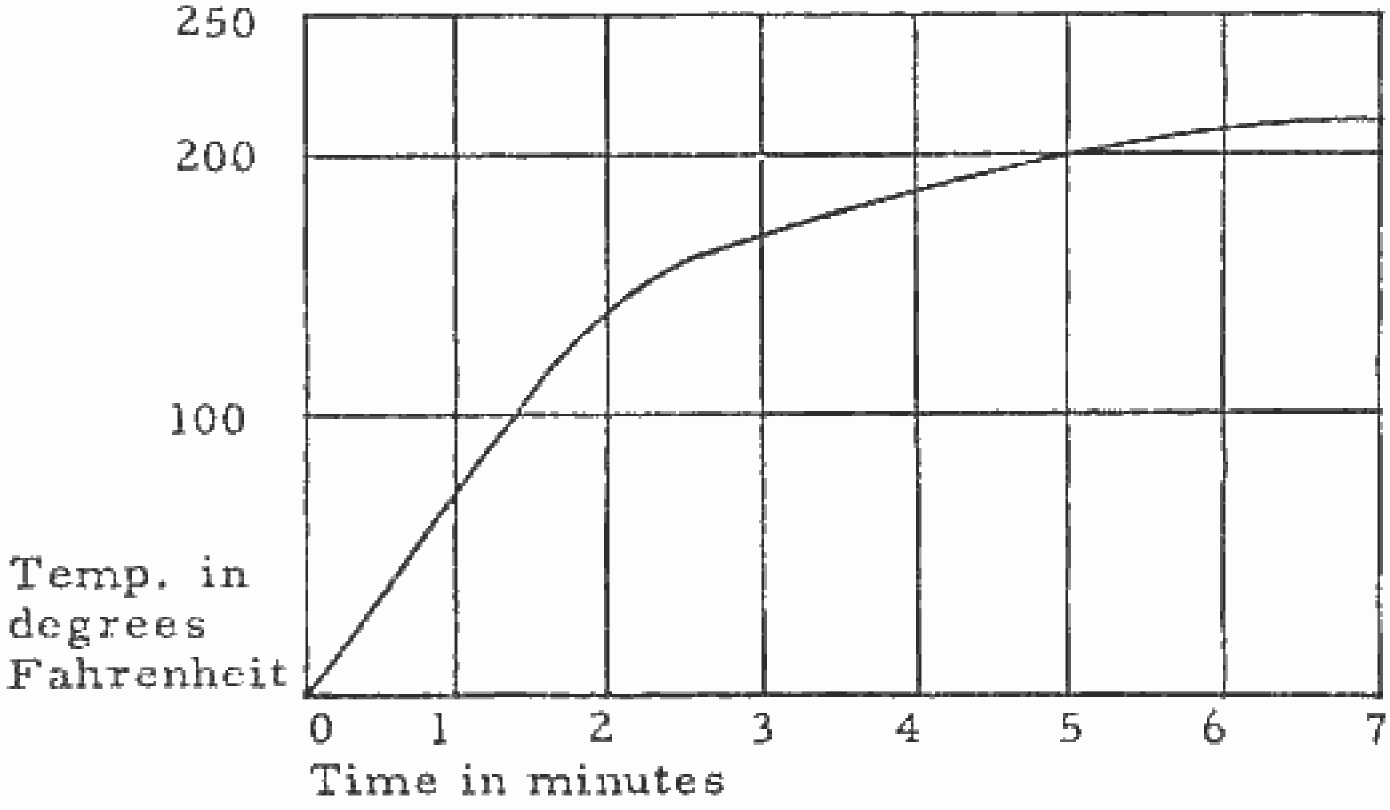


Figure 7.

Rate of temperature increase on surface 6" from 250 watt infra-red heat lamp.

rapidly. If the time element is extended, it is very possible that the bulb will rupture. Electric light bulbs begin to lose their shape after 10 minutes exposure to temperatures of 900 degrees F. or more, and shortly after this, the glass envelope will begin to flow. When this happens, the outer covering of the bulb loses its integrity and the extremely hot filament may come into direct contact with the flammable material. The heat lamp is constructed of heavier glass, and because of this factor, the probability of the heat lamp achieving this state should not be anticipated.

The infra-red heat lamp can also function as a valuable adjunct to the initiatory process. If the use of one of the less volatile flammable liquids is contemplated in conjunction with a continuous spark-type initiator, the lamp, focused on a container of the liquid, will cause rapid evolution of flammable or explosive vapor. Quite a bit of heat is generated at the surface of the substance if the infra-red bulb is aimed at its surface at close range. At a distance of six inches, the heat rise, and the time required for this amount of heat rise, are illustrated by the foregoing graph. (Fig. 7)

Temperatures fully adequate for the purpose may be quickly generated even in a cold room, since radiated heat is not absorbed by air to any extent, together with the fact that heat radiation is largely in the red and the infra-red portions of the spectrum.

9. Electromagnets:

The electromagnet as an initiator is something of a paradox. It provides the fundamental principle of the relay, does not produce heat in any appreciable amount, and yet is very applicable to the practice of arson. Its physical makeup is exactly the same as the core of the relay, except that it

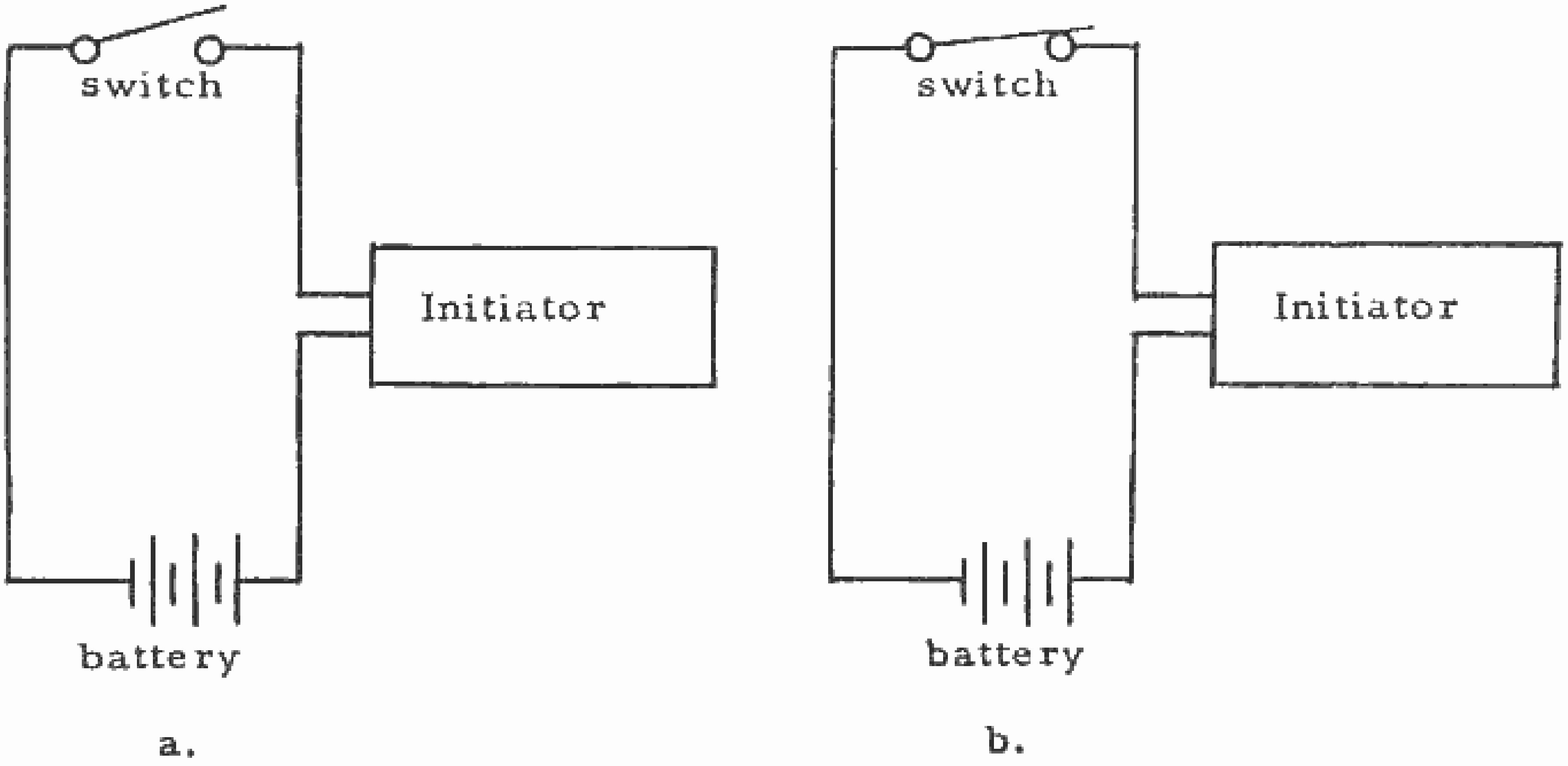


Figure 8.

is usually larger and more powerful. It consists of a great number of turns of insulated wire wound on a core of soft iron. When electricity is passed through the wire, the core becomes magnetic and remains so until the current is broken.

Its value in arson lies in its ability to mix dissimilar chemicals on command. One chemical is merely placed in a metal container and suspended above the other by a continuously energized electromagnet. When the current is removed, the container falls and the incident takes place. Variations of this technique will be discussed in the sections to follow.

V. BASIC CIRCUITS:

Up to this point, much attention has been given to materials that will burn or explode, and to devices that will set them afire or detonate them. These items are, in essence, the fundamental building blocks of any arson or explosion and, in the case of the initiators mentioned, more peculiar to electronic arson. Once these inherent needs have been fulfilled, the electronic aspects of the problem begin to take precedence.

The basic requirement in the employment of the initiating media and the initiators catalogued, is that a switch be opened or closed to begin the operational sequence. A source of electrical power must also be present, as all of the initiators listed are necessarily operable by remote control.

The two essential circuits, the primogenitors of all circuits that can find use in electronic arson, are shown in figure 8.

In figure 8-a, the initiator is activated when the switch is closed; in figure 8-b, the initiator functions when the switch is opened. The choice of the particular circuit used will depend upon the choice of initiator. In both of the illustrations, a battery supplies the power necessary, but the electrical supply may be drawn from a generator or from a power line.

One detail, unfortunately, makes these circuits unsuitable for use in electronic arson. This is the fact that the switches must be moved manually. Luckily, there is an easy

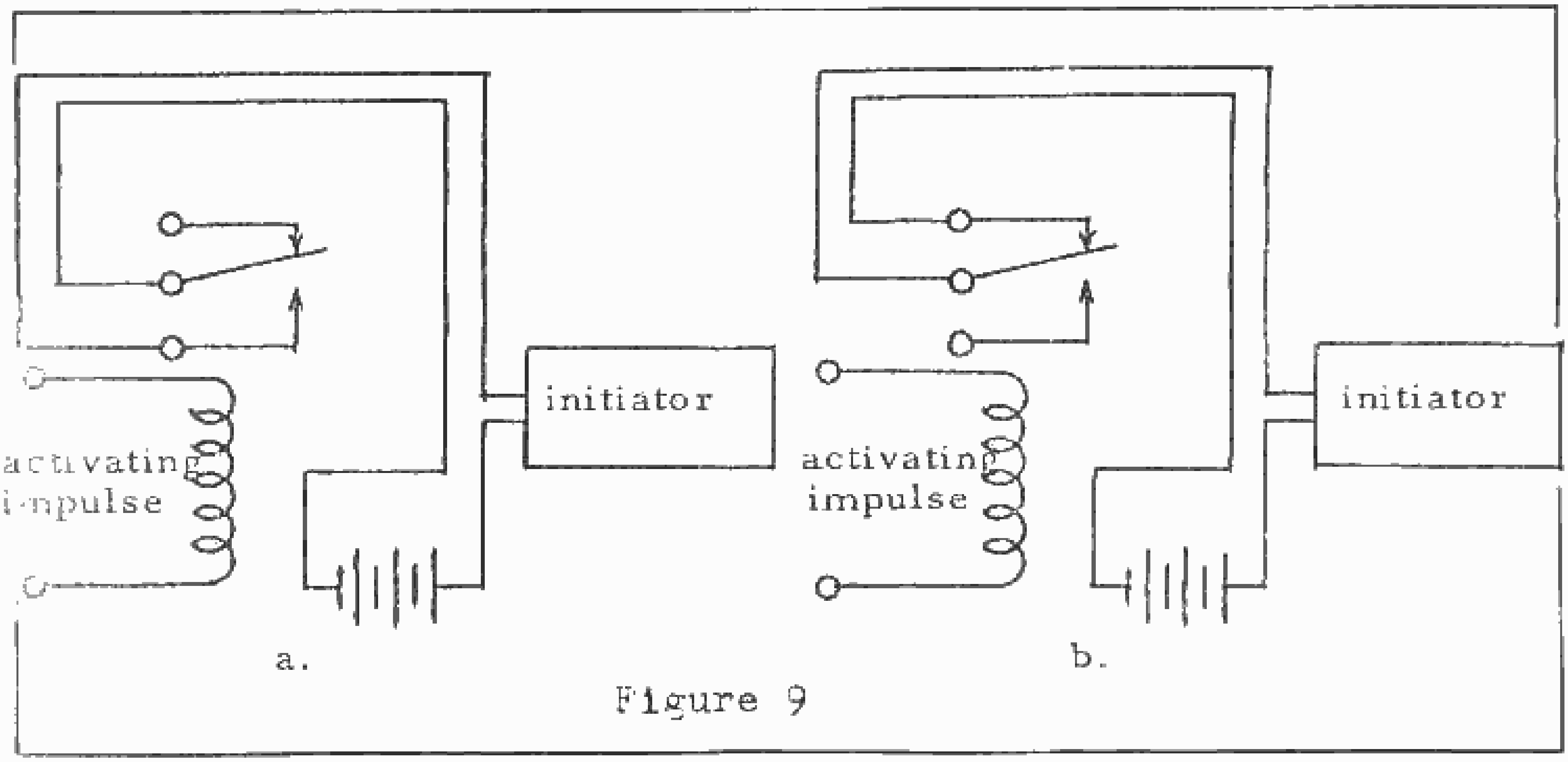


Figure 9

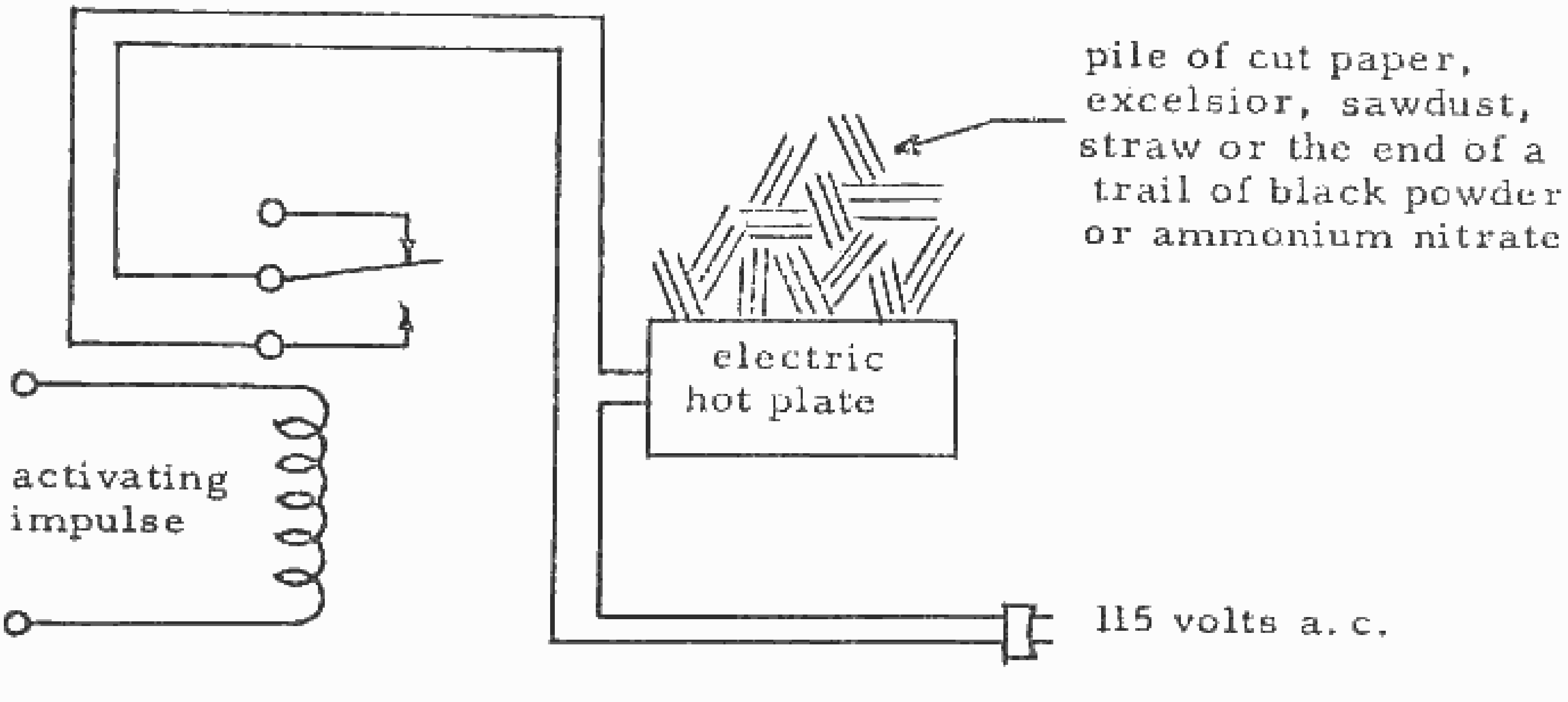

pile of cut paper, excelsior, sawdust, straw or the end of a trail of black powder or ammonium nitrate
electric hot plate
activating impulse
115 volts a. c.

Figure 10.

way out of the dilemma. Both circuits can be readily synthesized into a different form, an electrically operated relay being substituted for the switch. (Fig. 9)

Here, an impulse from an electronic trigger mechanism energizes the relay, closing the lower pair of contacts in figure 9-a, and opening the upper pair of contacts in figure 9-b.

Although the list of initiating media and initiators is far from being completely comprehensive, many combinations and permutations of these devices and materials may be evolved. Consummation of the crime by electronics being the object, a relay must, in all instances, do the switching.

The circuit shown in figure 10 would probably provide the simplest method of originating an arson.

In such an application, the initial impulse closes the lower set of contacts on the relay, introducing 115 volts of electricity into the hot plate heating element. The plate comes quickly to maximum heat, igniting the flammable material.

In this particular situation, it is compulsory that a latching or a self-holding relay be utilized, otherwise a continous activating voltage would be required. Since it is most expeditious that triggering be accomplished by a single impulse, the ordinary relay would not be desirable. Latching relays (those that lock closed on a single impulse) are easily obtained, but a self-holding relay may be improvised by using a multiple contact relay. (Fig. 11)

As shown in this diagram, both sets of relay contacts move simultaneously when the initiating push button is momentarily depressed. The top contacts function the same as those in figure 10, but the bottom pair, upon closing, feed a constant voltage to the activating coil, thus making it "self-holding"; that is, the contacts remain closed. In the interest of simplification, subsequent circuits requiring the use of such a relay will not show the additional wiring needed; the relay will be merely labeled "latching" or "self-holding."

The modern electric range or oven would furnish a ready-made and self-contained method of arson, a method analogous to the foregoing circuits. Flammable materials may

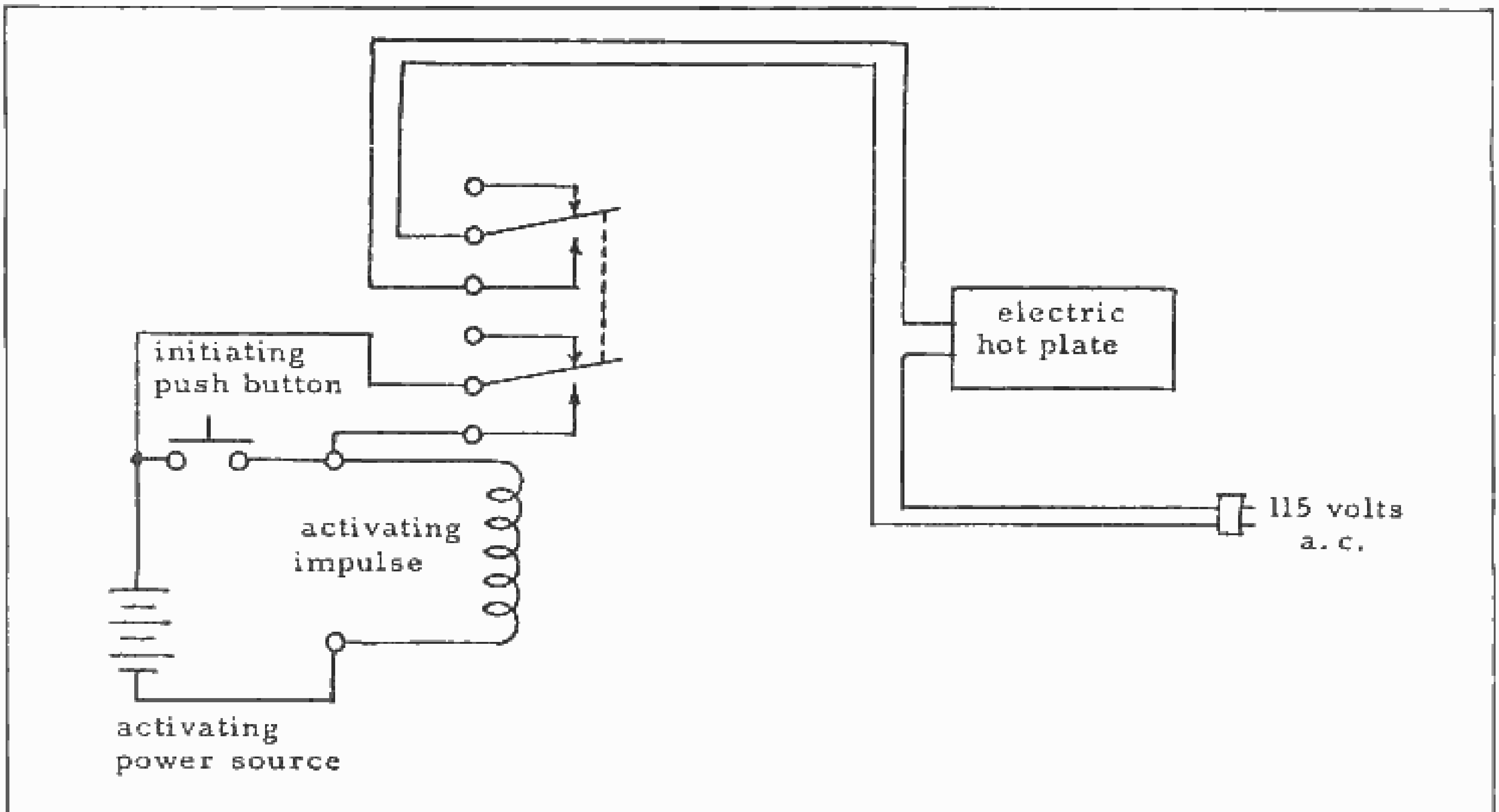


Figure 11.

be piled on the surface of the range, or flammable trails may be led from the heating element in an electric oven and the "plant" triggered with the oven's integral timer. A tightly closed gallon can of paint or lacquer brought to high heat in an open oven, will burst and scatter the burning material with disasterous results.

Variations of the circuits already shown are depicted in figures 12-a and 12-b. It is not essential that a commercial heating unit be used, as it is possible to purchase random lengths of nichrome wire. As mentioned earlier, this wire may also be removed from heaters and some hot plates. In these set-ups, the nichrome wire glows red shortly after the application of an electrical current, and the flammable material promptly ignites.

The "plant" in figure 12-b requires the use of plastic containers for the flammable liquid. The *plastic* will disintegrate rapidly under the heat, thus liberating the liquid to come into direct contact with the red-hot wire. Care should be taken that the plastic container chosen does not disintegrate prematurely under the action of the liquid itself.

It should also be kept in mind that nichrome wire has a finite amount of electrical resistance. Caution must be exercised that too great a length of the wire is not used for the power available. Too much resistance in conjunction with too little power will be manifested in too low a temperature capability of the initiator. Failure will be the end product.

Following a fire set with one of these contrivances, traces of the relay may be found in the residue. The frames of some hot plates might be of steel heavy enough to survive. Portions of the heating elements or the nichrome wire might be found, since they are built to withstand greatly elevated temperatures. If the hot plate utilizes nichrome wire embedded in a moulded retainer of refractory ceramic, it is almost certain that pieces of this

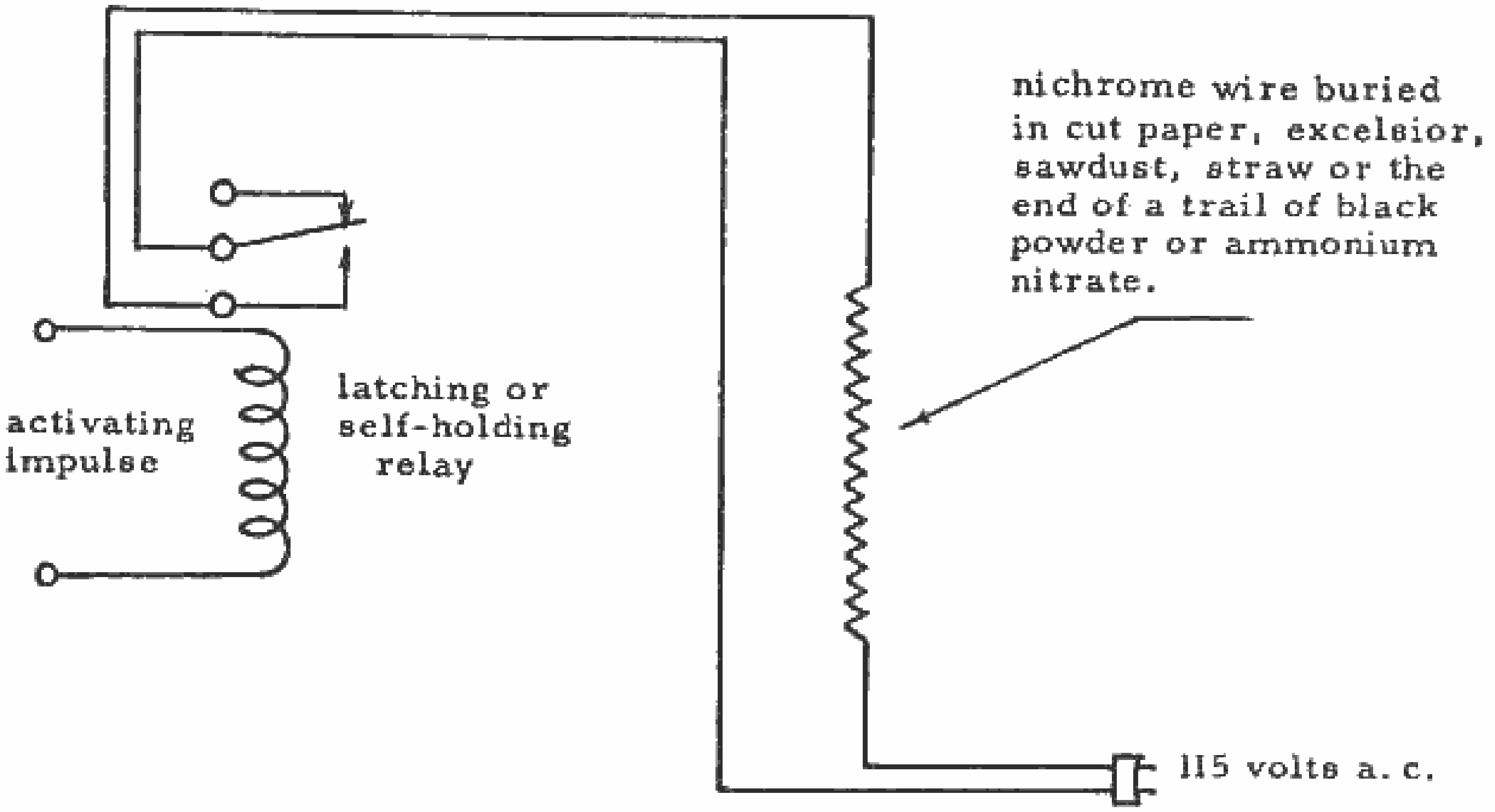

nichrome wire buried in cut paper, excelsior, sawdust, straw or the end of a trail of black powder or ammonium nitrate.
latching or self-holding relay
activating impulse
115 volts a. c.

Figure 12-a

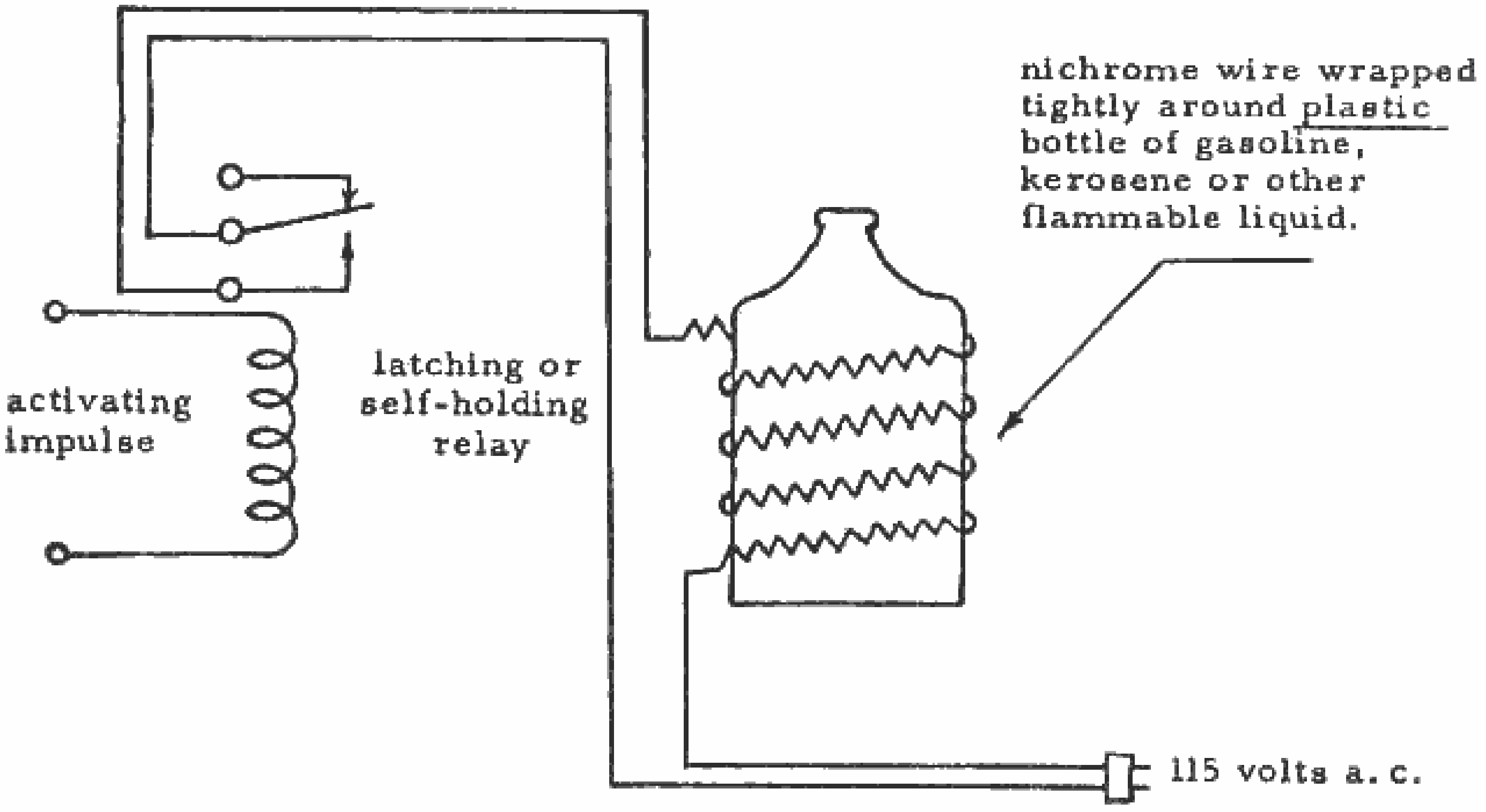

nichrome wire wrapped tightly around plastic bottle of gasoline, kerosene or other flammable liquid.
latching or self-holding relay
activating impulse
115 volts a. c.

Figure 12-b.

obdurate material will be found at the fire site.

The electric squib is attractive as an initiator, and offers the additional dividend of be-

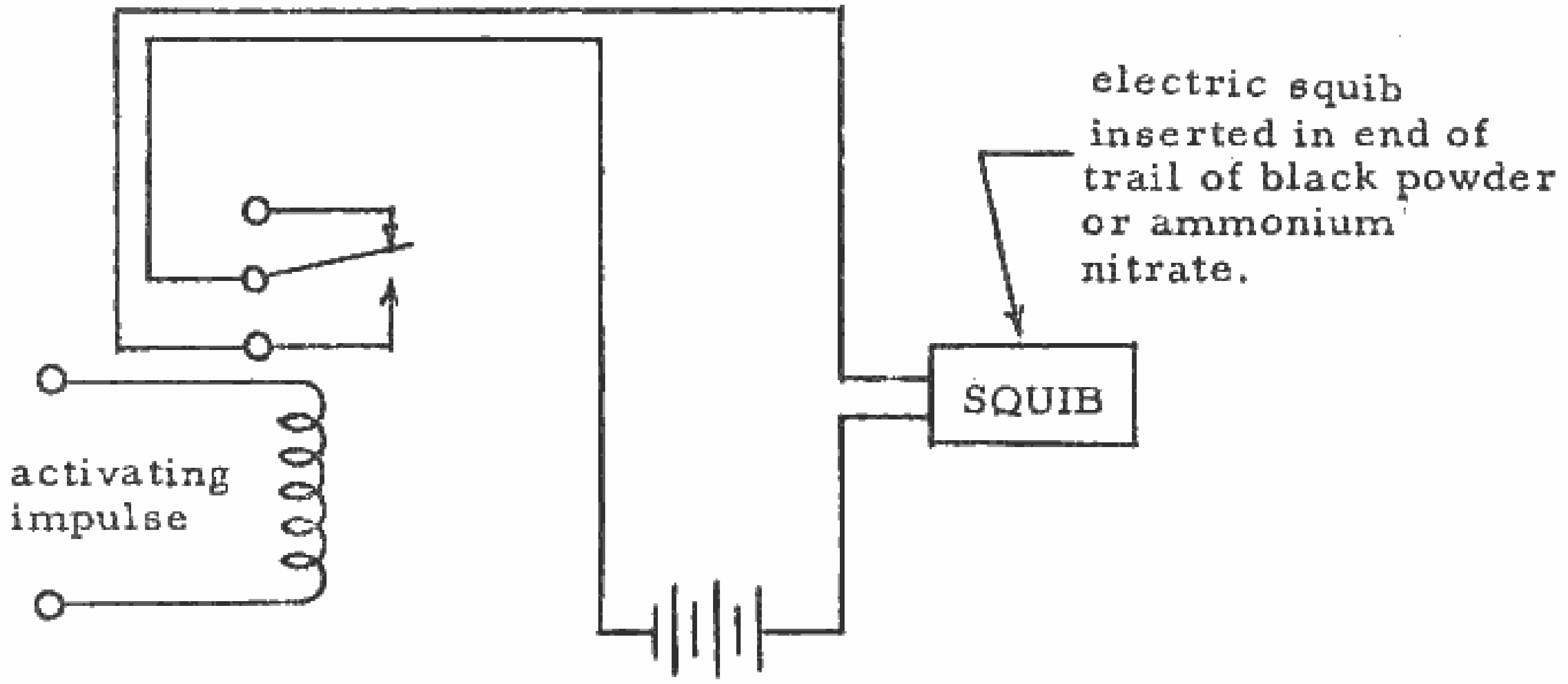

electric squib inserted in end of trail of black powder or ammonium nitrate.
SQUIB
activating impulse

Figure 13-a.

ing operable in an uninhabited building; i.e., one without a supply of electricity. A small dry-type battery will readily fire either an electric squib or an electric blasting cap with only a momentary passage of current. (Fig. 13-a, 13-b)

The method diagrammed in figure 13-a is "sure-fire." When the relay closes, a surge of electrical current is sent through the ignition charge within the squib, and the intense flame

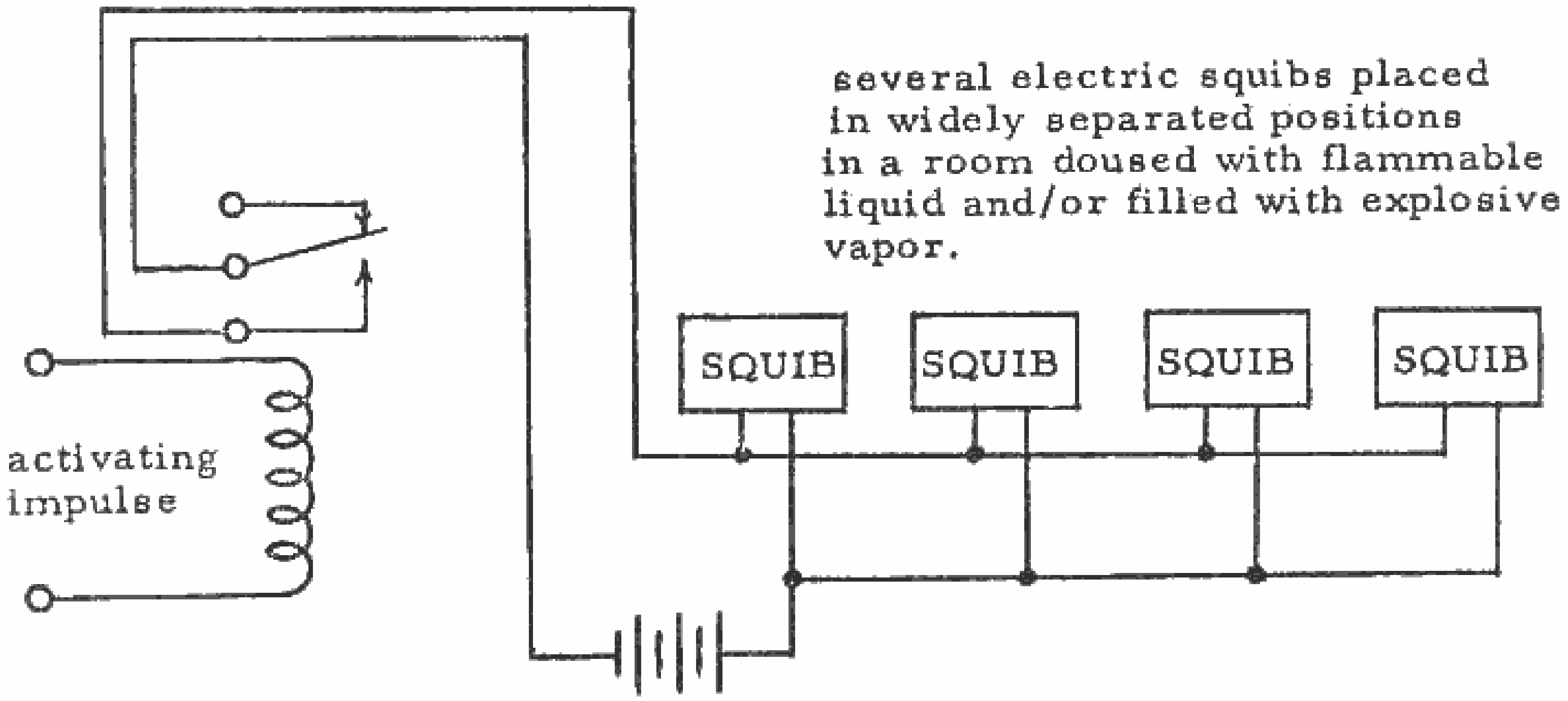

several electric squibs placed in widely separated positions in a room doused with flammable liquid and/or filled with explosive vapor.
SQUIB
SQUIB
SQUIB
SQUIB
activating impulse

Figure 13-b.

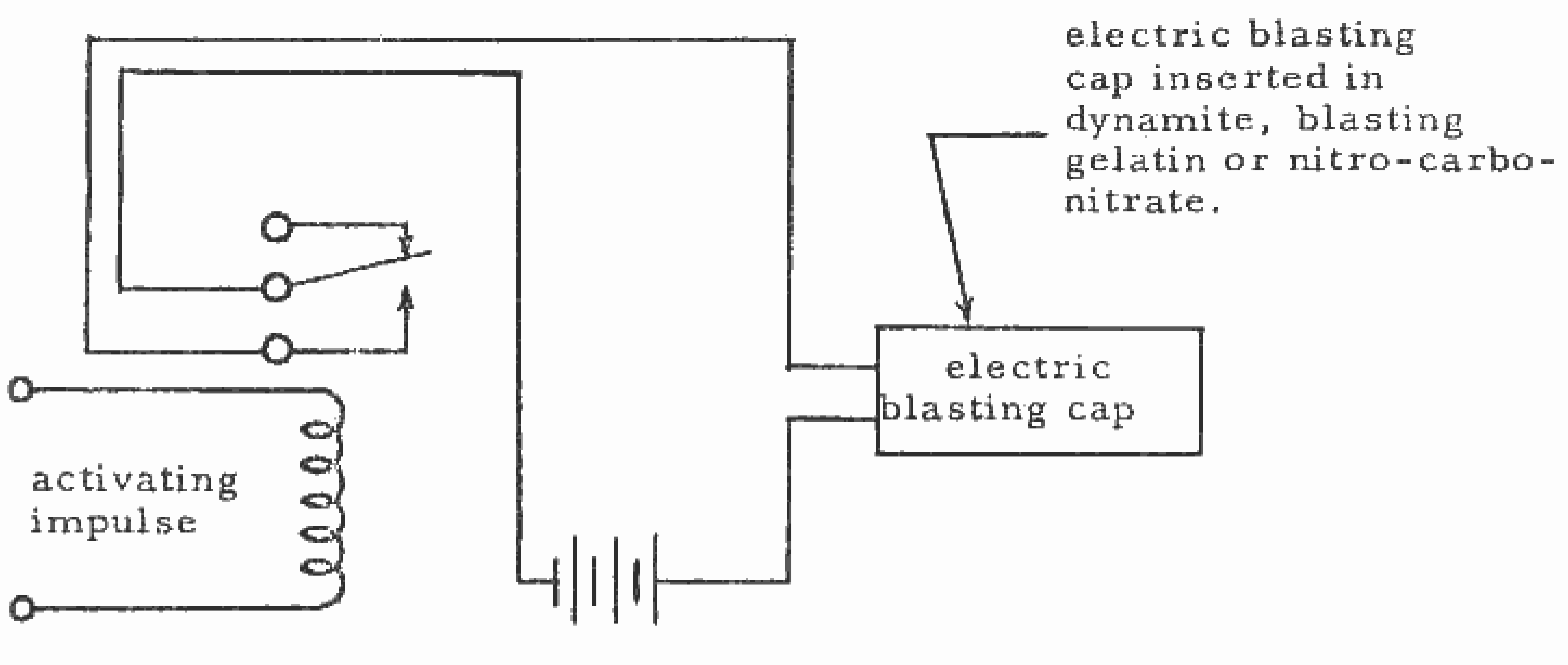

electric blasting cap inserted in dynamite, blasting gelatin or nitro-carbo-nitrate.
electric blasting cap
activating impulse

Figure 14.

issuing therefrom will, with certainty, cause initiation of the flammable substance.

The circuit shown in figure 13-b will work well, but has intrinsic unreliable aspects. As set forth earlier, liquids that evolve explosive vapors, as well as most potentially explosive products normally found in gaseous form, possess certain limitations with regard to the amount of vapor present in a given volume of air. A one-time-only flame, such as the squib

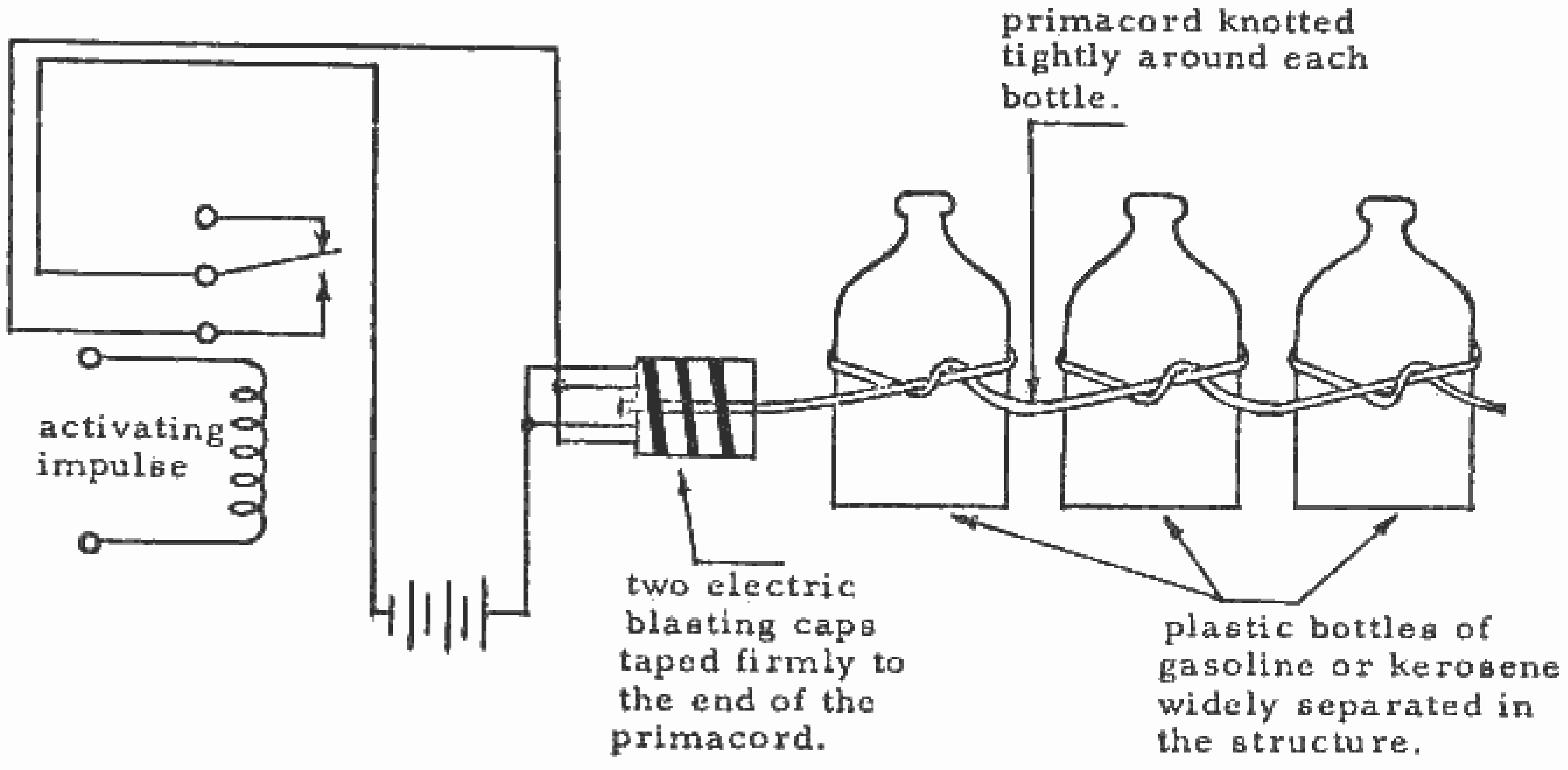

primacord knotted tightly around each bottle.
activating impulse
two electric blasting caps taped firmly to the end of the primacord.
plastic bottles of gasoline or kerosene widely separated in the structure.

Figure 15.

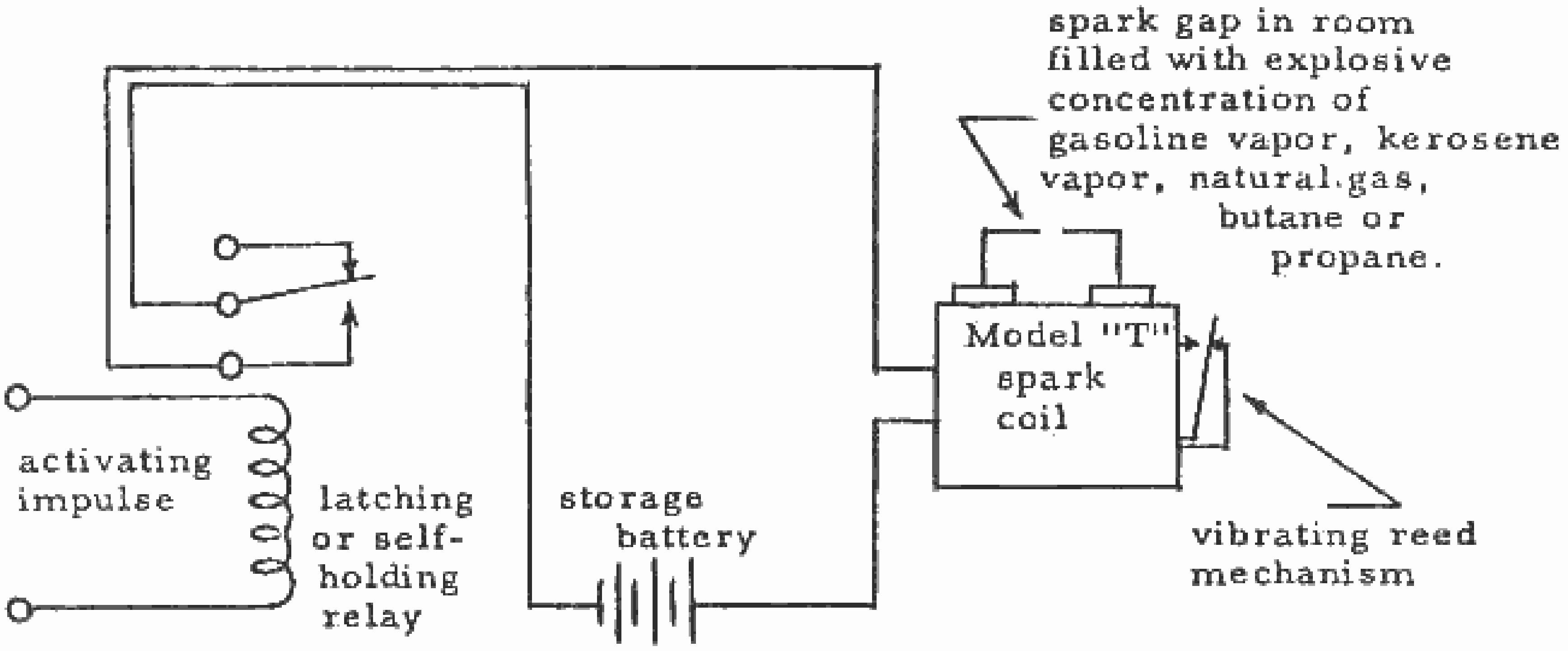

spark gap in room filled with explosive concentration of gasoline vapor, kerosene vapor, natural gas, butane or propane.
Model "T" spark coil
vibrating reed mechanism
activating impulse
latching or self-holding relay
storage battery

Figure 16.

produces, just might occur at a moment when the vapor concentration is beneath or above the explosive limits of the particular material used.

Electric blasting caps may be fired in exactly the same manner. (Fig. 14)

A momentary electrical current is introduced into the cap, and detonation follows at once. The shock wave set up by the violent decomposition of the cap is more than enough to cause sympathetic detonation in most high explosives.

Primacord proves a valuable acccessory device in a circuit embodying features from se-

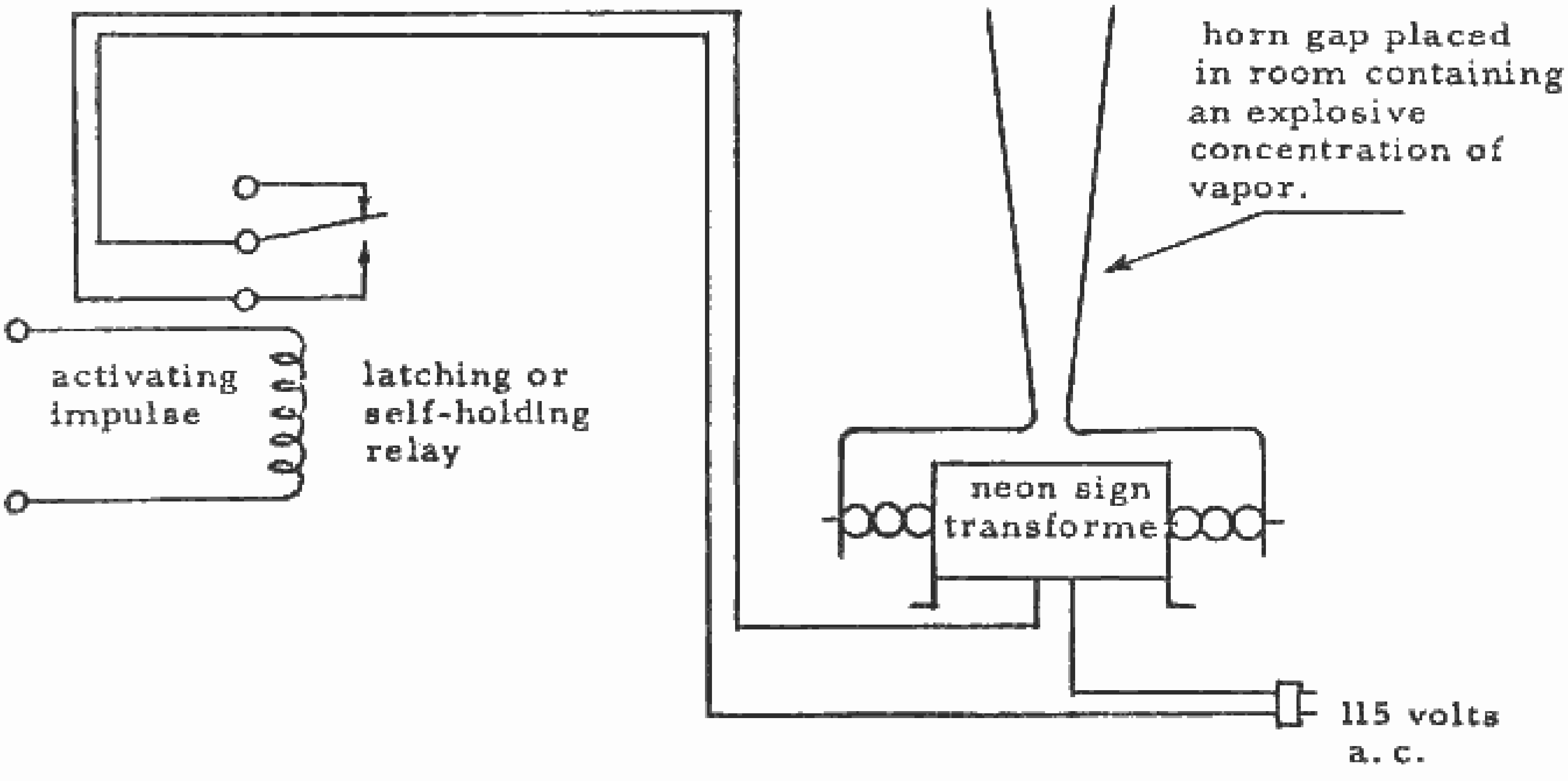

horn gap placed in room containing an explosive concentration of vapor.
activating impulse
latching or self-holding relay
neon sign transforme
115 volts a. c.

Figure 17.

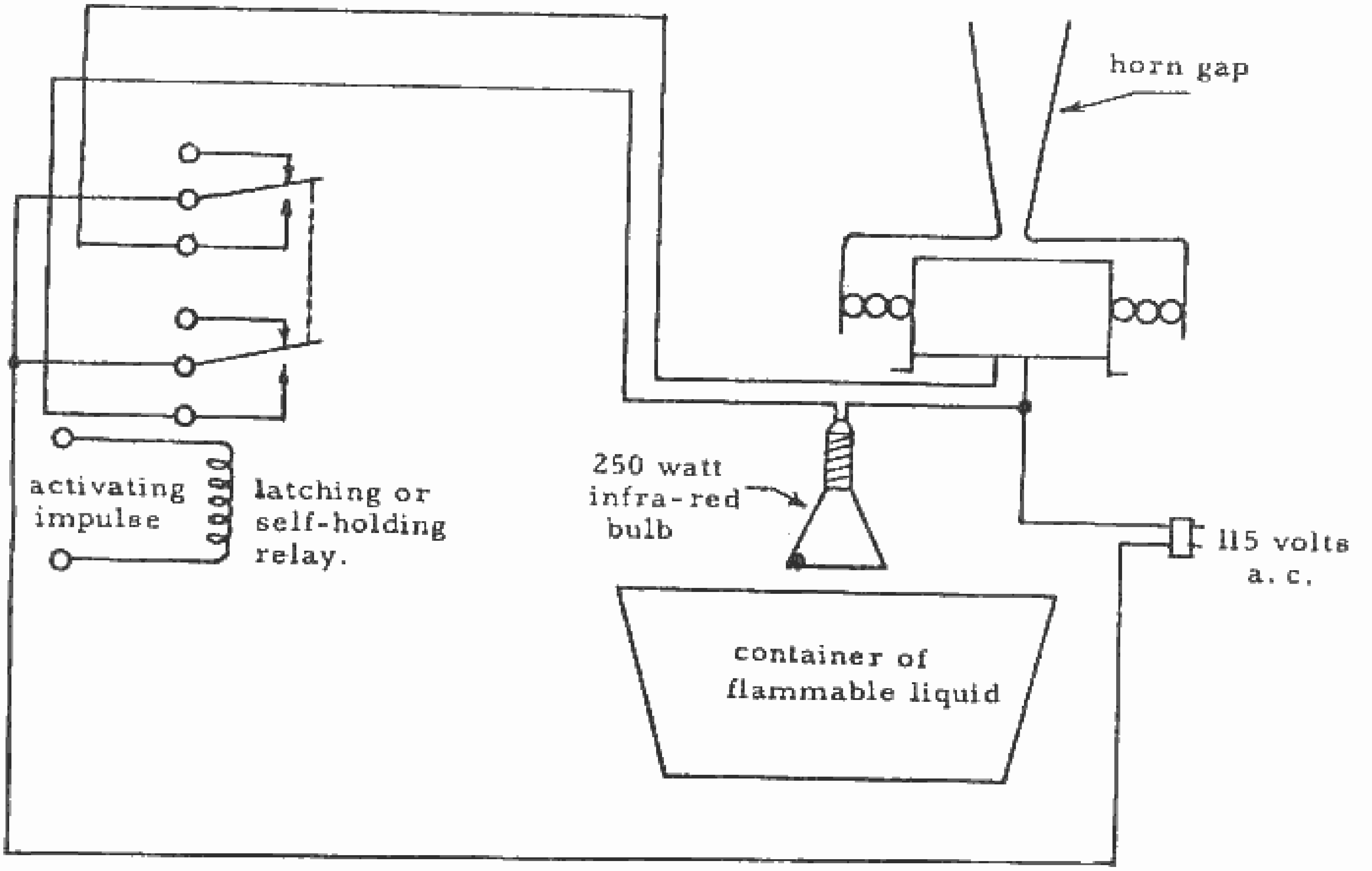


Figure 18

veral other configurations. (Fig. 15) This layout will cause rapid and wide-spread destruction. Actuation of the relay sends a momentary pulse of electricity to the blasting caps, detonating them. The primacord, having a core of highly explosive PETN, detonates from the ensuing shock wave, the detonation taking place at about 21,000 feet per second. A sudden high heat level accompanies the explosion. The bottles of gasoline are ripped apart by the explosion, the fluid is ignited by the heat, and the flaming material is hurled over a wide area. A large structure can be implanted with many such devices, and all may be fired simultaneously.

In all probability, the only thing left in the debris would be parts of the relay and fragments of plastic from the bottles.

The electric spark, because it can be arranged to recur over a long period of time, is a much more reliable way to touch off explosive vapors. Even though the volume of vapor present is not within the explosive limits of the substance used, the spark can continue until a suitable concentration of vapor has built up, or until an excess concentration has dwindled to the proper ratio. Figure 16 shows the connection of a model "T" spark coil. A six volt wet storage battery should be used if the spark is to continue for any length of time.

The action is exactly the same as that shown in figure 16, except that a longer and more effective spark is furnished by the horn gap.

Electric light bulbs may be utilized following the schematic hookup in figure 10. The main stipulation in their successful employment is that they must be well insulated from

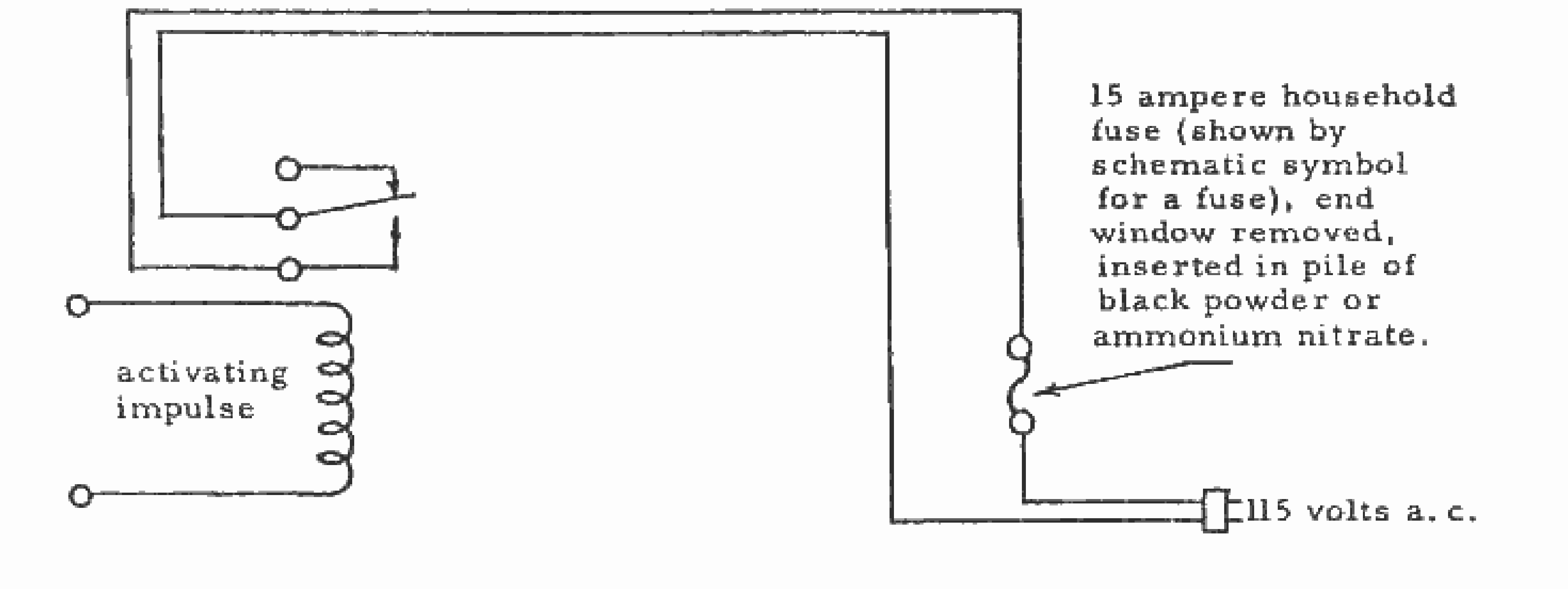

15 ampere household fuse (shown by schematic symbol for a fuse), end window removed, inserted in pile of black powder or ammonium nitrate.
activating impulse
115 volts a.c.

Figure 19.

the ambient air by the flammable material, accumulation of heat being the object.

If attempt is made to initiate an arson with a spark gap and one of the less volatile flammable liquids, the addition of a multiple contact relay and an infra-red heat bulb will increase the chances for satisfactory performance. (Fig. 18)

This would be a useful technique in conjunction with the heavier fuel oils. Number four oil, for example, has a minimum flash point of 130 degrees Fahrenheit. If the heat of the oil is brought up above this critical temperature, vapors are evolved that will be almost as dangerous as gasoline vapor. Best of all, the correct concentration of vapor in the surrounding air is assured. Rapid evolution of vapor does not begin to take place until the

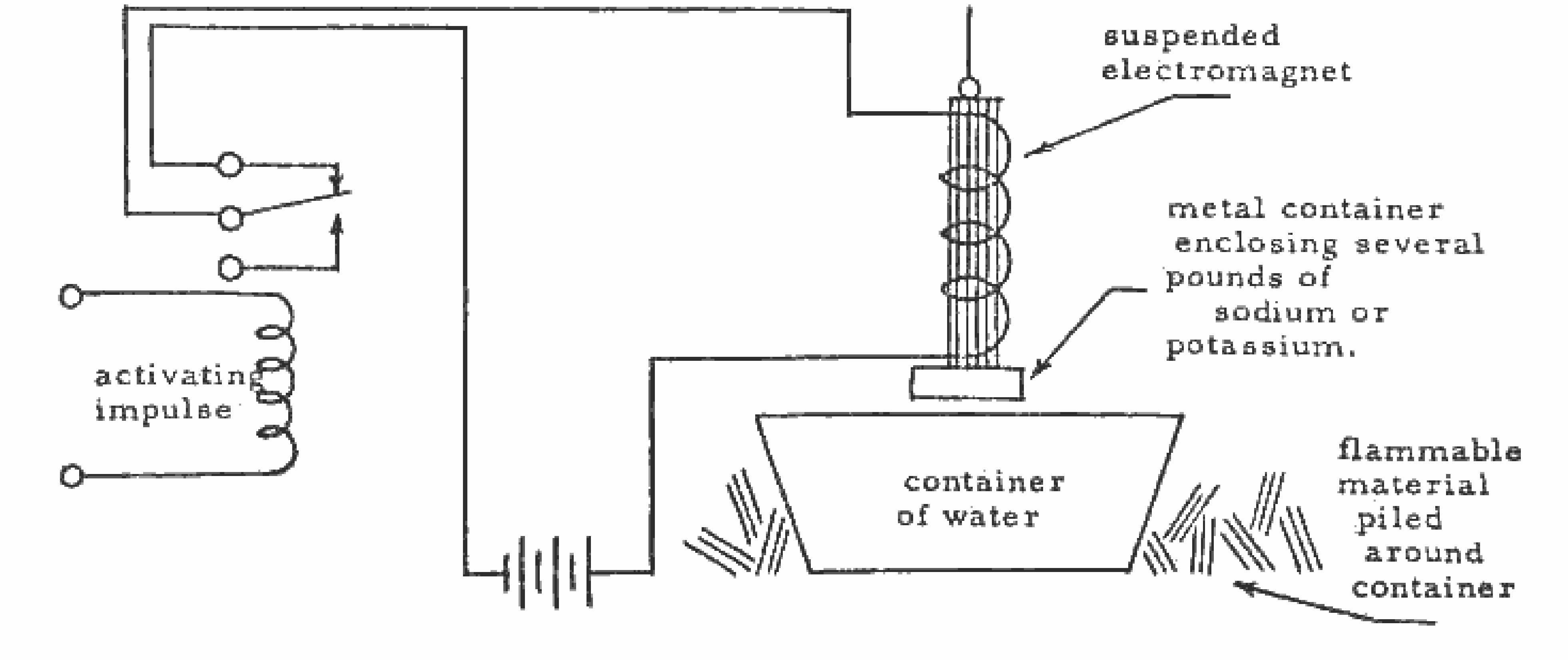

suspended electromagnet
metal container enclosing several pounds of sodium or potassium.
activating impulse
container of water
flammable material piled around container

Figure 20.

heat from the bulb strikes the oil. When it does begin, the concentration increases until the amount passes through the lower explosive limits. At this point, ignition occurs. A short element of time delay after the initial triggering is an extra dividend furnished by this method.

After an incident involving spark gaps, parts of the units may be found in the fire residue. These units, incorporating induction coils in one type and a huge step-up factor in the other, contain dense masses of small wire wound on solid metal cores. In addition, the windings are often "potted"; that is, impregnated or dipped in transformer varnish or tar-like substance to prevent the intrusion of moisture during normal operation. The smell of burning or recently burned impregnating material is characteristic and, once encountered, will be easily recognized. The neon transformers are usually supplied in heavy steel cases. Portions of the heat lamps may survive. Often having an outer covering of pyrex glass, they can withstand temperatures that would completely obliterate an ordinary bulb.

The efficacy of the household fuse as an initiator has already been set forth in another section. A fuse of the older variety, one having a mica end window, is desired. Its firing circuit is uncomplicated. (Fig. 19)

Note that it is not necessary to use a latching or self-holding relay. A single impulse to the relay's activating coil will cause disruption of the fusible link and, accompanying the incident, an intense flash of flame. If black powder is employed, the fuse should not be buried too deeply.

The photographic flash bulb may be fired by the same circuit, but a flashlight battery will furnish enough power to do the job.

It is unusual to think of the electromagnet per se in terms of arson initiation but nevertheless, it will work. (Fig. 20)

Notice the difference in the connection of the relay contacts. Here, the activating impulse *opens* the top pair of contacts, breaks the circuit energizing the electromagnet, and the container of chemical falls into the water.

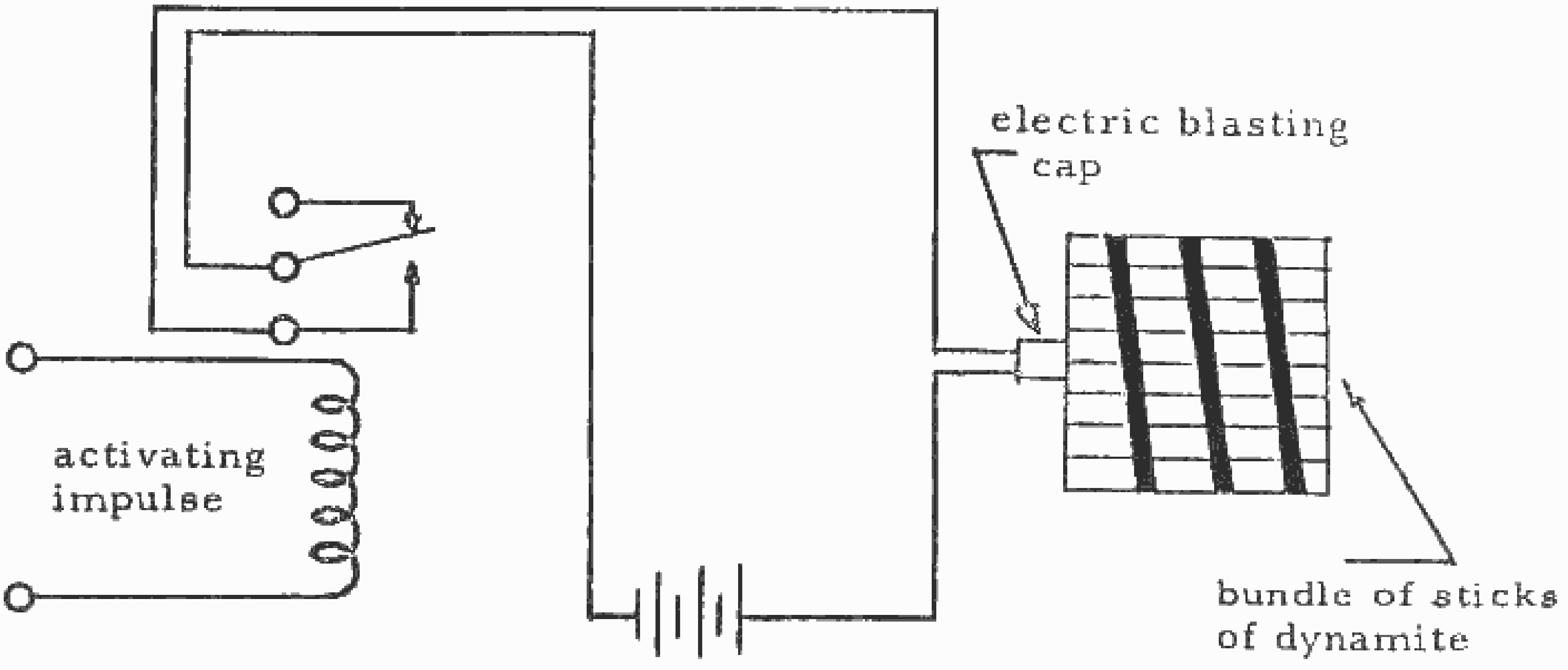


Figure 21.

The resulting violent decomposition ignites the flammable material piled near the water container.

A battery is shown as the magnet's power supply, but certain arrangements can be made to operate it from an alternating current source. If a battery is used, care should be taken that the unit does not become depleted and drop the container prematurely.

All of the circuits described heretofore are uncomplicated and straightforward. These, however, may be expanded into truly diabolical mechanisms; mechanisms that can grow to a huge scale. Take the simple detonation of an explosive charge as a case in point. (Fig. 21)

A triggering pulse of electricity is sent to the activating coil of the relay, the relay closes, a pulse of electricity from the battery is fed to the blasting cap, the cap detonates, and sympathetic detonation takes place in the

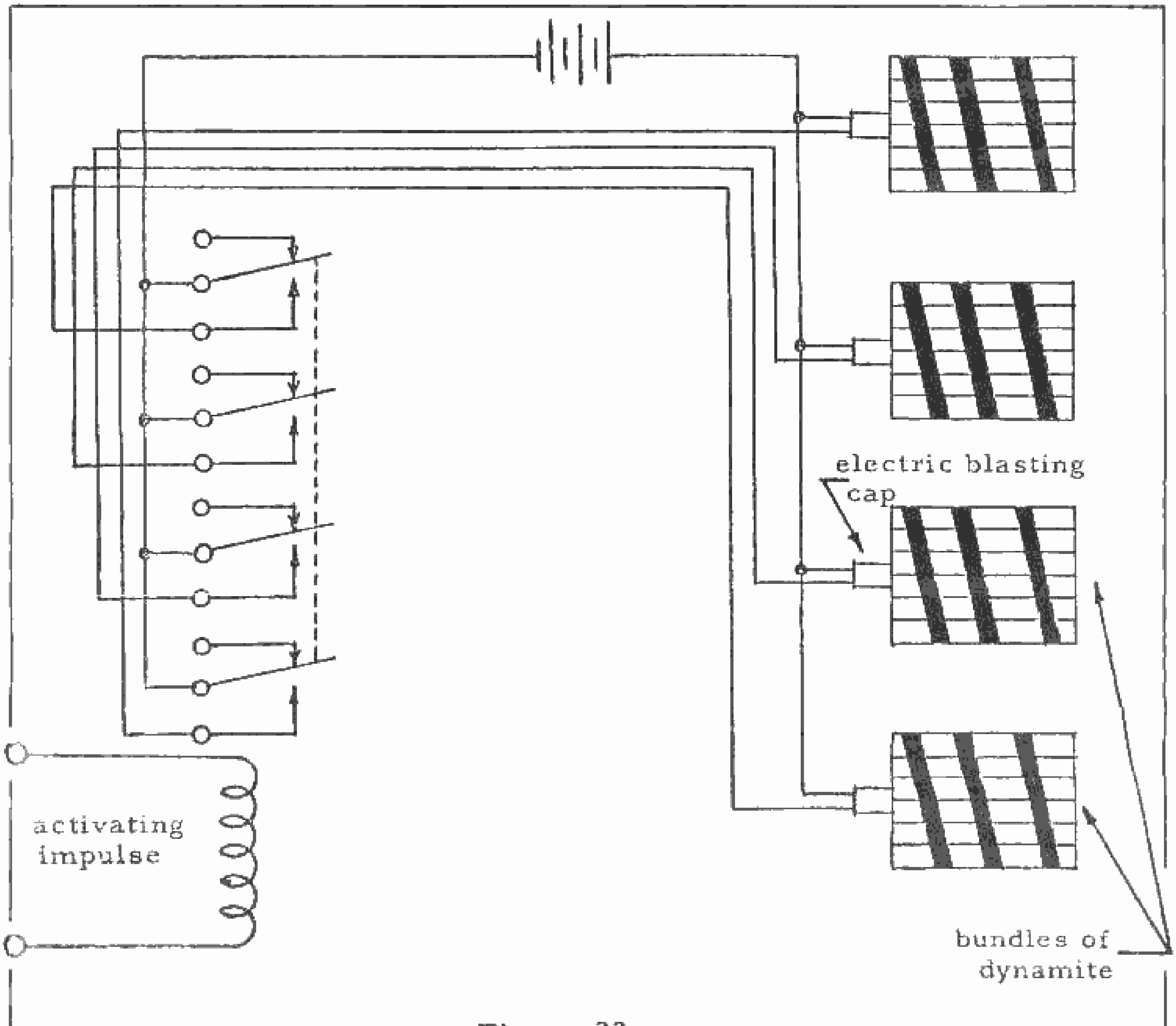


Figure 22.

dynamite.

This will cause great damage in a small structure or under favorable environmental conditions, in a larger structure. But suppose conditions are *not* favorable; suppose the structure slated for demolition is *much* larger. Then this circuit, with the use of a different relay, more wire and more explosives, may be expanded into this. (Fig. 22)

Action is the same as the circuit in figure 21, with the exception that each pair of relay contacts fires an individual explosive charge upon closing. Taking care to provide enough power to compensate for extra-long wire length, the charges may be widely separated in a building. Nor is the number of charges limited to the four shown. Each firing circuit may be subdivided by parallel connections and the number of contact pairs in the relay may be increased, so that the individual "plants" may number in the hundreds if need be.

Perhaps the arsonist wishes to be "cute"; perhaps he or she has developed a special dislike for law enforcement authorities or for members of the fire services; perhaps he just likes a good show for his money. A little extra time and effort and a sequential relay will give him one. (Fig. 23)

The explosive charges are placed at vantage points that will permit the blasts to inflict a maximum amount of structural damage. The

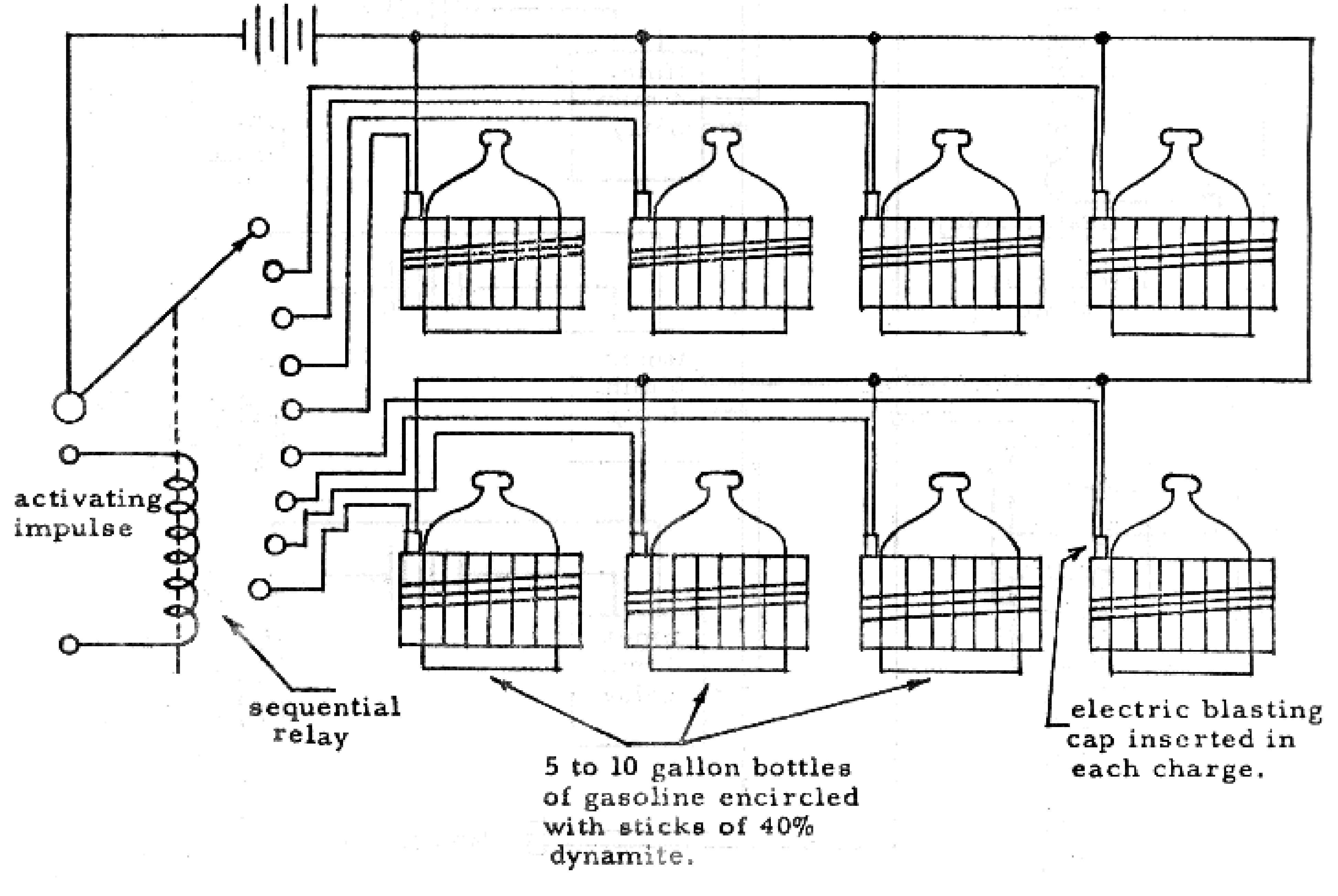

activating impulse
sequential relay
5 to 10 gallon bottles of gasoline encircled with sticks of 40% dynamite.
electric blasting cap inserted in each charge.

Figure 23.

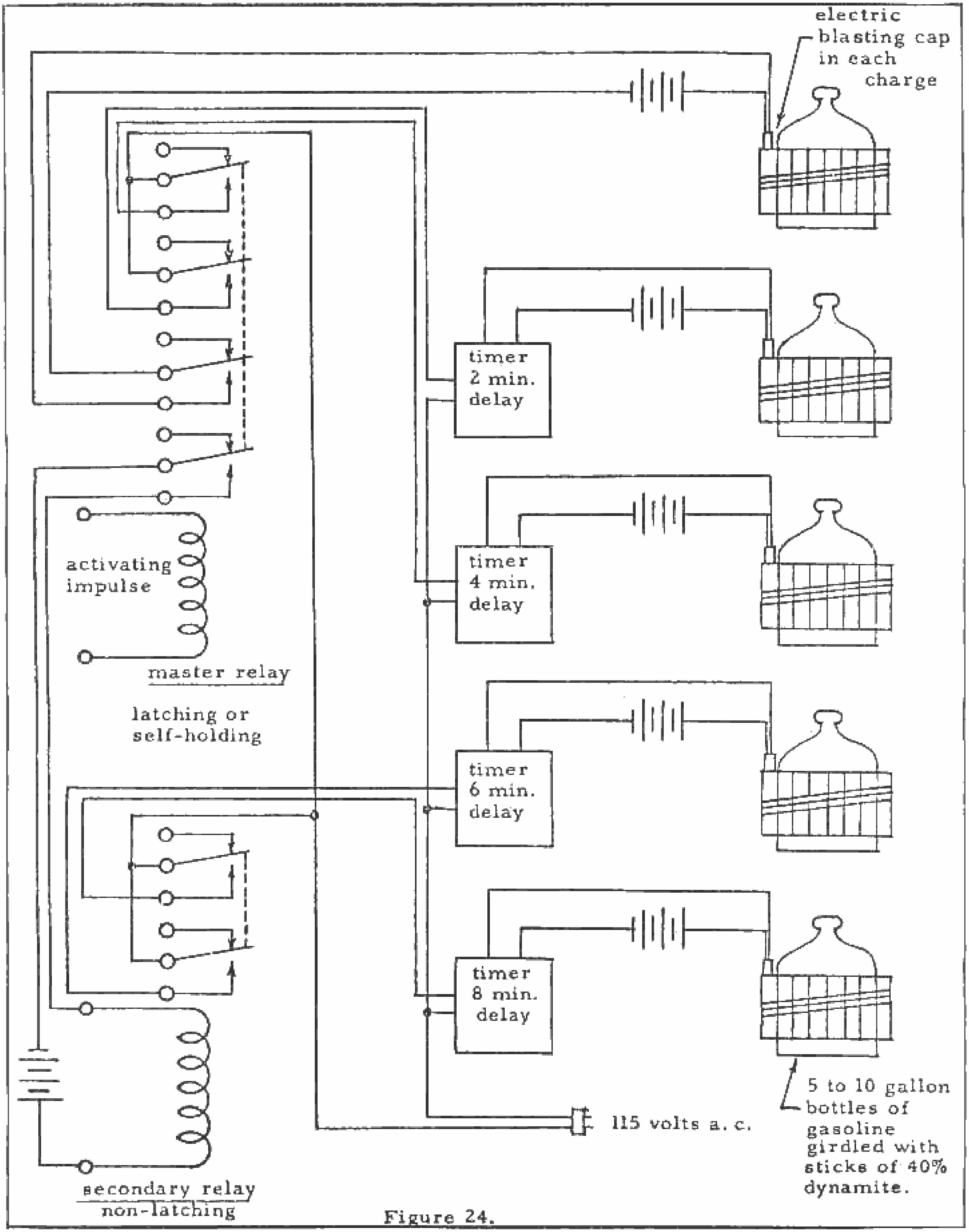

electric blasting cap in each charge
timer 2 min. delay
timer 4 min. delay
timer 6 min. delay
timer 8 min. delay
activating impulse
master relay
latching or self-holding
secondary relay
non-latching
115 volts a. c.
5 to 10 gallon bottles of gasoline girdled with sticks of 40% dynamite.

Figure 24.

explosions also break the bottles, ignite the gasoline, and hurl it throughout the building. Each time an incoming electrical impulse enters the actuating coil of the relay, the stepping mechanism moves one notch, firing the explosive charge connected to it. The charges may be spread over a large area. If the arsonist occupies a commanding position where he can watch the progress of the fire, he can detonate the explosive units at his leisure. He may choose to wait until the fire services have begun their battle before firing all of them.

But perhaps he is squeamish; perhaps he would rather be far removed from the scene of the incident. If so, he can use this kind of circuit to accomplish the same result with thoroughly predictable accuracy. (Fig. 24)

The circuitry exhibits some unusual features. Notice that two relays are used, and that they are connected in "cascade"; that is, the closing of one relay effects the closing of another. This broadens the potential number of circuits that can be operated electrically to an unlimited amount. Only one pair of contacts in a multiple contact relay need be utilized in energizing a succeeding relay.

The employment of electrically powered timers is quite different from the basic circuits heretofore described. These provide an extremely essential function in this hookup.

A single actuating impulse arrives at the master relay. All contacts snap closed and remain closed, the action closing the secondary relay. At the instant the contacts operate, the number one explosive/gasoline "plant" is set off. At the same time, all of the electrically operated timers begin to run. Each of these is set in increments of two minutes from the time of the initial impulse. Every two minutes, one of the timers runs out its course, and another charge is detonated. Since the fire services almost always arrive on the scene in well under five minutes, they should be actively at work fighting the fire before the detonation of the final charges. Placement of charges should not be such as to disrupt the flow of electricity to the timers.

With electronics, the size and the complexity of the "plant" are unlimited.

One link in the chain of electronic arson

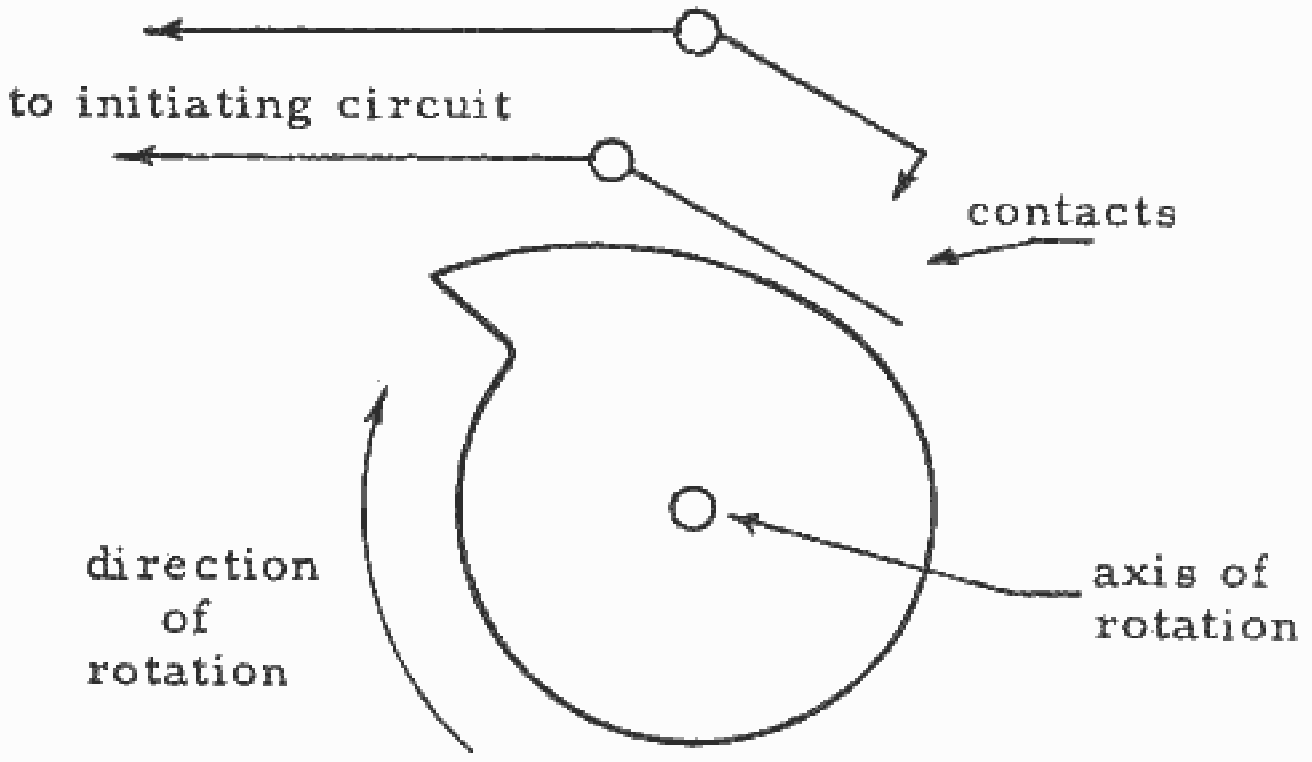


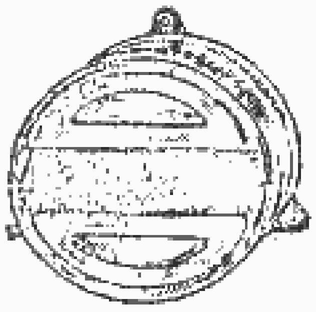
Figure 25.

remains unforged. One question remains unanswered. *How can the activating relay be opened or closed by remote control?* It is here that the full impact of electronics is felt, and the remaining portion of this manual will be devoted to some of the answers to that question. Shakespeare had a word for it: "All the rest is prologue."

VI. TIMERS:

Timers occupy a unique position among the host of electronic triggering mechanisms extant. Operating by means of principles mechanical as well as electrical in nature they form, as it were, the bridge or the connecting link between conventional arson and electronic arson. Such devices have been welcomed by criminals over the past years becuase of the facility with which they may be applied, because of the case in which they may be obtained, and because of their efficiency and reliability.

In earlier applications, most of these units were strictly mechanical, consisting of a spring-driven clockwork movement which, after a predetermined period of time, closed a spring-driven clockwork movement which, after a predetermined period of time, closed a switch. Often, similar contrivances were improvised from quite ordinary alarm clocks. The mechanical action is elementary.(Fig. 25 A cam or some other animating protrusion is arranged to rotate on a clockwork-driven shaft. The shaft revolves until the point of maximum projection arrives under the blades of the switch. Pressure from the protuberance closes the contacts, and the initiator is triggered.



(illustration about
one-half actual size)

Figure 26.

Although sometimes very crude in their makeup, these gadgets have always been popular with the do-it-yourself-bombers, and many successful crimes are on record that had mechanical timers at their hearts.

Spring-driven timers possessed one great advantage. Since they were not reliant on a supply of electricity, they would work anywhere. They could be (and have been) sent through the mails while operating. Despite this good feature, one unfavorable salient point predominated. Because their springs had to be wound on occasion, they were primarily short term devices; i.e., they usually were unable to run for more than a day or two.

Most of the modern timers are electrically driven. Spring-driven timers still exist but are, for the most part, confined to uses requiring short intervals of one hour or less. Spring-driven timers are frequently used in the photographic darkroom and, while they are handily available in many places, are not practical in the commission of arson because of their short time-measuring capabilities.

In the electrically driven timer, the customary means of propulsion is a small synchronous motor. (Fig. 26) These are habitually furnished sealed in cases of thin brass or other metal. They are found in all sorts of timing devices as well as in commonplace electric clocks. Their ultimate action is the same as that described in figure 25. The motor moves a clockwork gear train, and some kind of cam closes a pair of contacts at a pre-set moment. At times, these units are incorporated in regular home appliances that utilize a timing function. Sometimes they are self-contained. Commonly they are rather simple in their particular service. Often they can perform a complex series of operations.

Figure 27 shows a self-contained timer of a type that will be quickly recognized by most people.

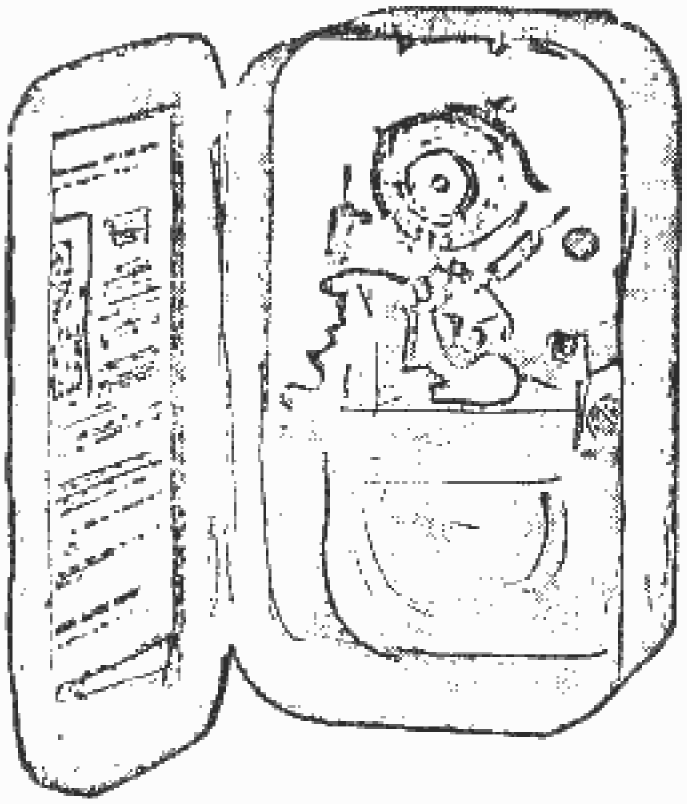


Figure 27.

This species has been of inestimable aid to the farmer and to the industrial user for a long period of years. In the above illustration, a little above the center, the timing calibrations can be seen marking off the hours and the subdivisions thereof. The drive motor and its associated gear train is located behind the panel on which the dial is mounted. Note the heaviness of the case; it is ordinarily made of steel.

In operation, the motor slowly revolves the calibrated dial. "Trippers" or small metal fingers are attached to the dial at the time marking desired. When the dial reaches this point, the contacts close. This kind of timer can be purchased almost anywhere at a cost of about eight dollars. With this mechanism, as with all other timers, the contacts, together with a battery or an alternating current supply, may be used to operate the activating relay or the contacts may, in certain instances, be used *as* the activating relay.

The foregoing unit is somewhat limited in that its dial makes one complete revolution in a twenty-four hour span. However, for an additional five dollars or so, a similar unit can be had that is calibrated in increments of seven days as well as in hourly sections. This feature widens considerably the timer's possible scope of usage in electronic arson.

More decorative and compact variations of this basic generic unit are on the market. (Fig. 28)

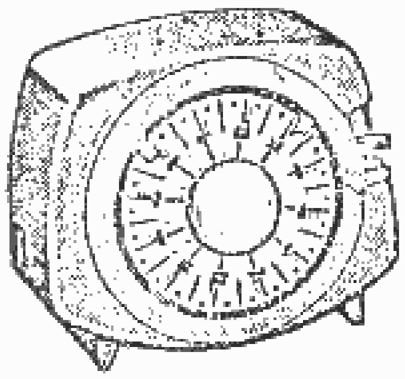


Figure 28.

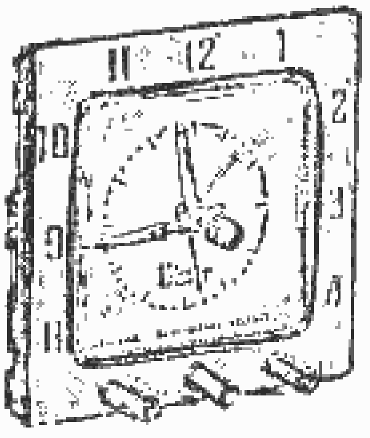


Figure 29.

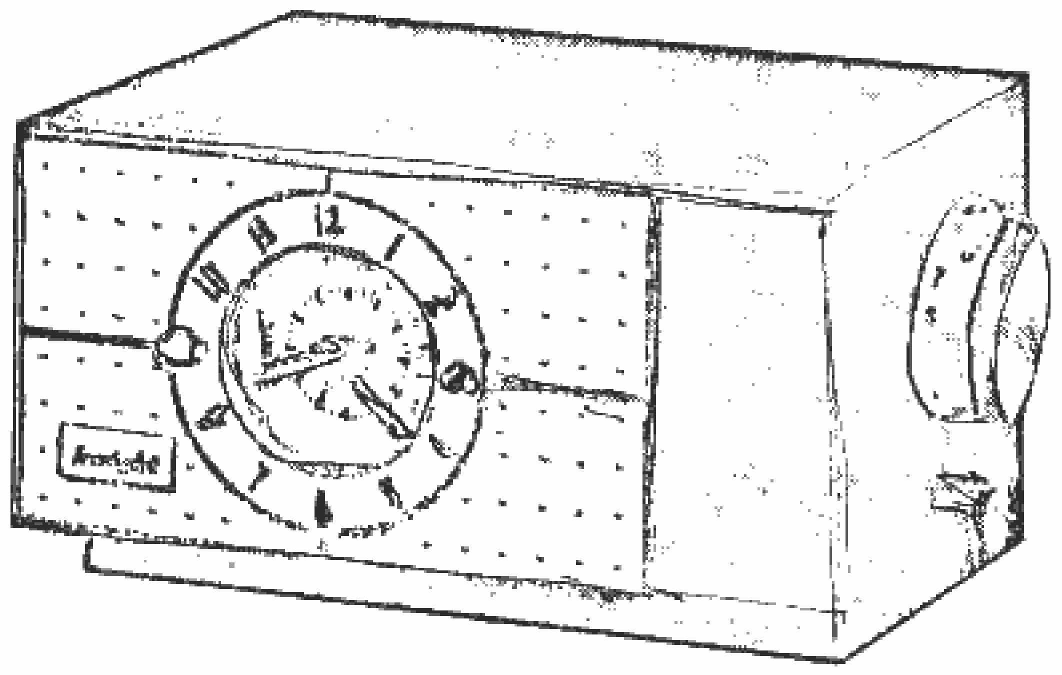
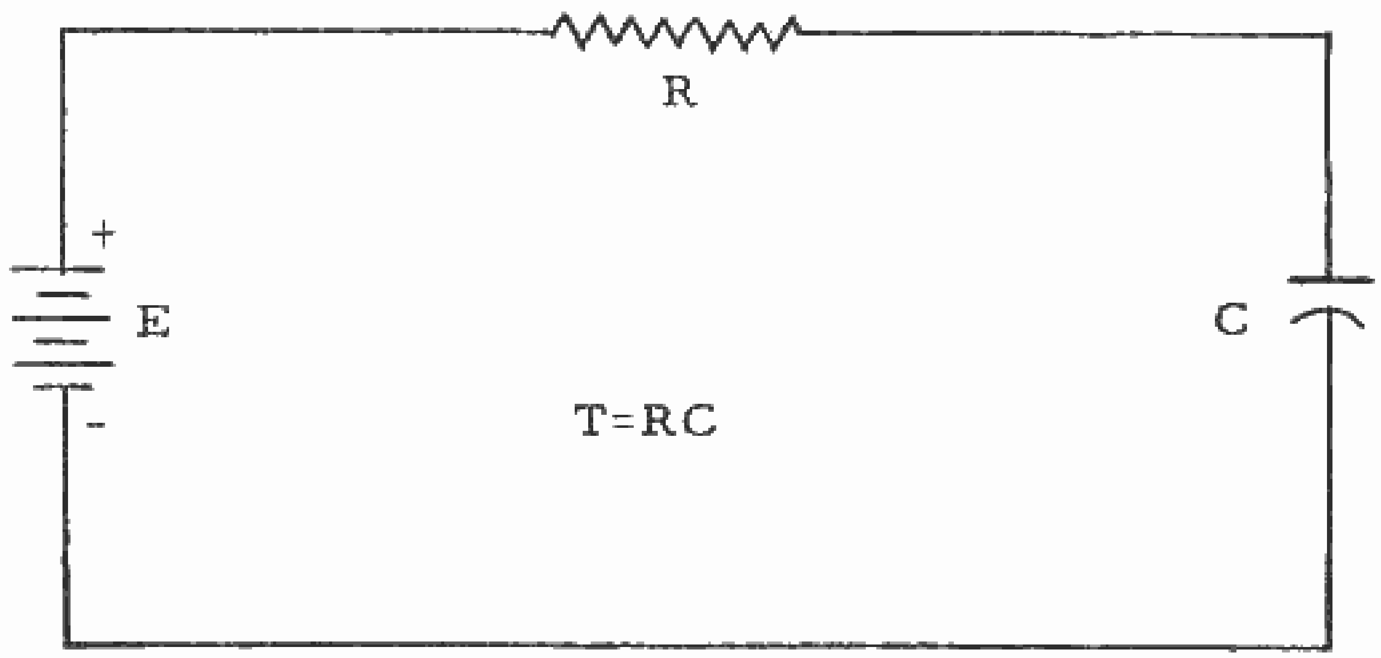


Figure 30.

The steel-clad devices were built for permanent, long-term operation; the smaller, plastic-enclosed articles were intended for incidental use within the immediate living area of a home. The operation of both is the same, nevertheless, and the plastic unit, while not so impressive, is by no means ineffective.

Even smaller, uncased versions of this type of timer are built into many home appliances of recent design. Elaborate devices of this nature are incorporated in most automatic washers. These quite often possess the ability to initiate a sequential series of events, and could be readily subverted to the arsonist's use were



T is the time in seconds
R is the resistance in ohms
C is the capacitance in farads

Figure 31.

it not for two qualificatory facts; they must be started manually, and they run their entire course within one-half hour to forty-five minutes.

Comparable timers are contained in most of the modern electric ovens. (Fig. 29)
In reality, these consist of nothing more than an electric clock set to run constantly, and a trigger mechanism operated by the clock that may be set to function at a given time.

An even more familiar mode of utilization of this kind of timer is its inclusion within a so-called "clock-radio." (Fig. 30)
The terminology is somewhat misleading. The timer is merely a unit of a variety quite ordinary in every sense of the word, except that it is contained in the same case with the radio. Internal circuitry is such that the clock/timer may be set to energize the radio at a given instant. In almost all cases, an auxiliary outlet is comprehended in the unit for the purpose of actuating some external device at the same moment.

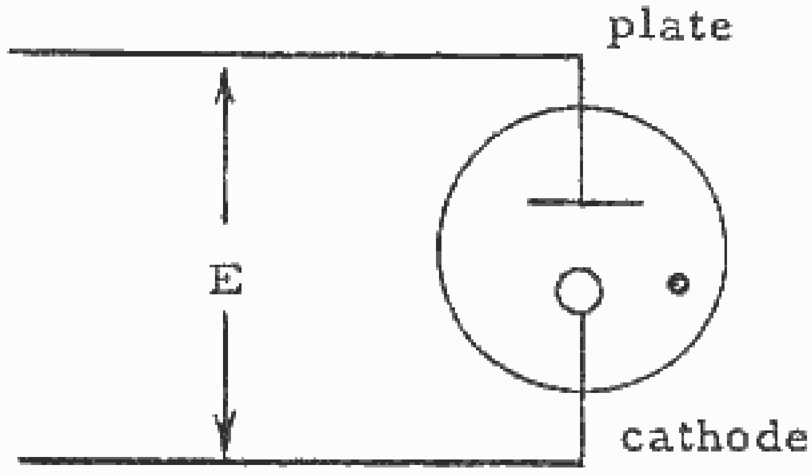
All prior considerations regarding timers have dealt with their electro-mechanical characteristics, and this may have given rise to the impression that mechanical linkages are essential to chronological mensuration. This is definitely not true, and it is here that we find the bridge into pure arson by electronics.

The operation of exclusively electronic timers is founded upon two fundamental principals. When a resistance and a capacitance are connected in series in a circuit, and a voltage is impressed across that circuit as in figure 31, the hookup is said to possess a time-constant.

In unadorned phraseology, this is the time required for capacitor "C" to charge through resistor "R" to the applied voltage "E." As may be expected, the time constant of a circuit will vary with the size of the resistor and the size of the capacitor. This relationship is expressed in the formula T=RC.

The second precept concerns the gas-filled tube. While the great majority of vacuum tubes have, as their name implies, been highly evacuated, some are deliberately filled with rather exotic gases at low pressure. If a voltage is introduced across the tube's internal electrodes as in figure 32, an interesting phenomena takes place.

If the voltage is increased to a certain critical value, the gas within the tube ionizes, and a flow of current between the electrodes is set up. It may be observed that each tube so filled with gas exhibits a tendency for the gas to ionize and thereafter to conduct when an exact exciting voltage is reached peculiar to the particular tube in use. Prior to the ionized



(black dot indicates gas-filled tube)

Figure 32.

state, conduction of electricity through the tube does not occur.

Like some short-term mechanical timers, the electronic timer, as normally found in industry, also covers a brief time span. Devices of this general makeup are used in governing the length of welding processes, radio-frequency heating procedures, and countless other manufacturing practices.

Figure 33 illustrates an electronic timer that negates this limitation. In analysis, the circuit is really two separate resistance-capacitance circuits functioning by virtue of a common power supply. The flow of charging voltage into the second circuit is intermittently controlled by the repeated cycling of the first.

The detailed action is as follows. The switch is thrown, and capacitor C2 begins to accumulate a charge through resistors R3 and R4. When C2 charges to the ionizing potential of the first gas-filled tube V1, the tube suddenly conducts, a current flows through the actuating coil of relay 1, and the relay's con-

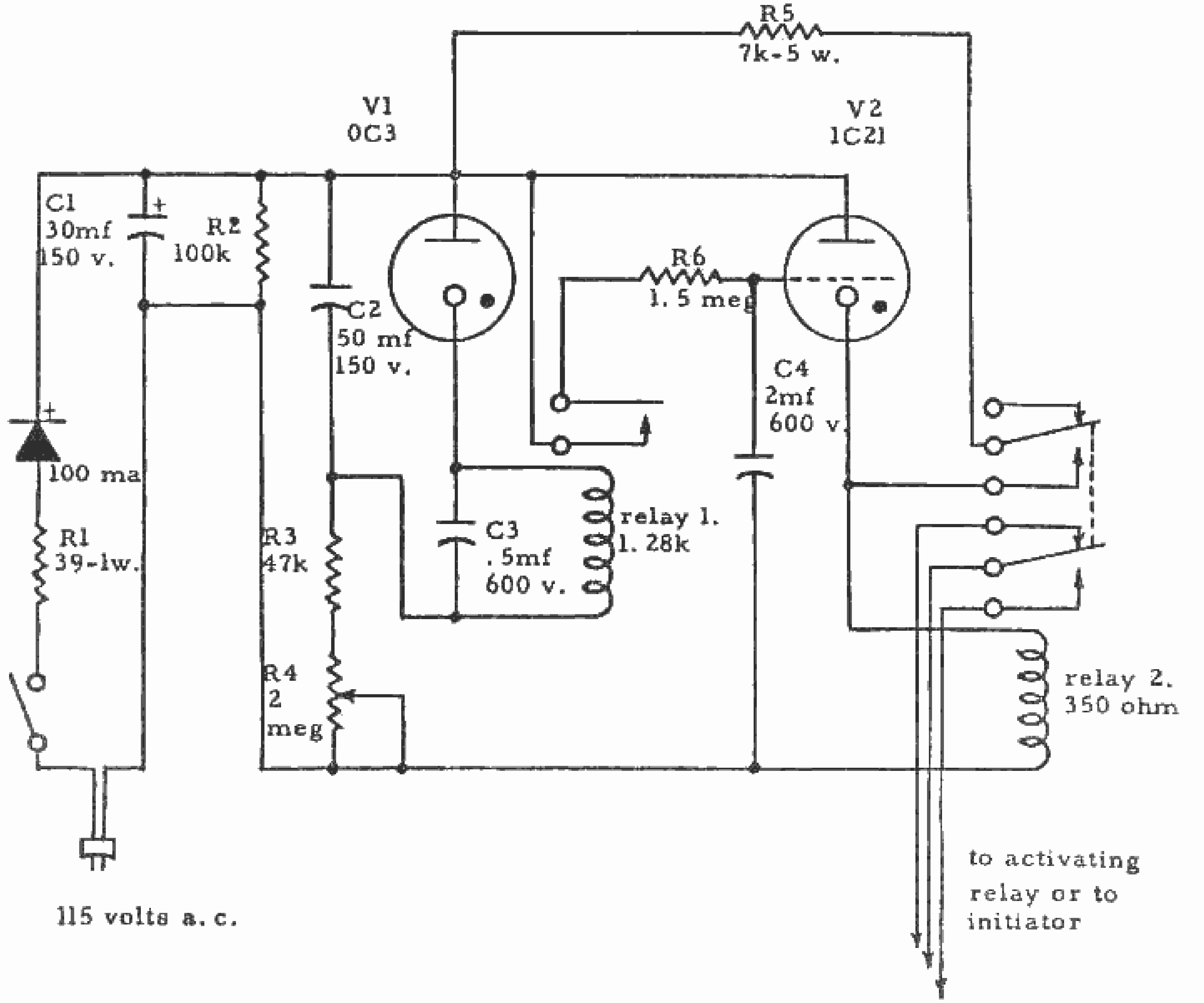

R5
7k-5 w.
V1
0C3
V2
1C21
C1
30mf
150 v.
+
R2
100k
C2
50 mf
150 v.
R6
1.5 meg
C4
2mf
600 v.
+
100 ma
R1
39-1w.
R3
47k
C3
.5mf
600 v.
relay 1.
1.28k
R4
2
meg
relay 2.
350 ohm
to activating
relay or to
initiator
115 volts a.c.

Figure 33.

tacts close. This causes capacitor C4 to begin to take on a charge through resistor R6. Meanwhile, the charge gathered by C2 is rapidly leaking away through the coil of relay 1, and through the tube V1. As soon as the charge falls below the voltage necessary to maintain ionization of the gas in V1, conduction through the tube is cut off. As a result, the contacts of relay 1 open, the charging of C4 is interrupted, and C2 begins to accumulate another charge. The cycle repeats itself again and again until C4 has achieved a charge sufficient to cause ionization in the second gas-filled tube V2. When this state is realized, relay 2 closes. Two of the accompanying contacts operate either the activating relay of the incendiary or explosive device or the device itself, and the other contacts supply the coil of relay 2 with a self-holding voltage.

The key to this unit that makes it so applicable to arson is the fact that the resistance-capacitance circuit made up of R6 and C4 displays a large time-constant, and by the fact that its charging voltage is supplied in brief increments. About 15 to 16 hours must pass before C4 can gather a charge great enough to operate relay 2. As R6 is enlarged in value, the time-constant increases until several days may be required for the relay to close.

The investigator may be assured that the use of timers in the initiation of arson will be most difficult to pin down. Because of their ubiquitous nature, and because they have every right to be present in the home, in the factory, or in practically any conceivable situation, it will be a burdensome task to prove that they had been placed at the suspected crime site for a nefarious purpose.

When timers are used in the commission of arson, the principal suspect may well be expected to be at some distance from the location of the event. He will probably be able to offer substantial proof that he could not possibly have been present at the point at which the crime originated at the time specified. He may have been in the company of reputable and highly respected citizens.

It is almost mandatory that the timer be used in connection with some electrical device, either a regular home appliance or a device especially contrived. Since timers that encompass periods of twenty-four hours or less are definitely in the majority, their use may be justifiably suspected if such time relationships are evident, and particularly if opportunity exists to initiate a crime through the application of some electrical apparatus. This peculiar time element should not be adopted as a general rule-of-thumb however, because the longer-term interval timers do exist and may be encountered.

If the use of a timer is suspected, look for evidences of the driving motor. Being encased in metal and possessing a driving coil wound on a metal armature, it may survive even though it would probably be distorted. Unless the resulting fire is unusually intense, the unit shown in figure 27 will certainly have the remains of the steel case as part of the fire residue. Keep in mind that it would not be a common practice to make use of such a timer in the habitable areas of a building.

Where clock-radios (figure 30) are employed, a variety of significant debris may be discovered. The bulk of all radio enclosures are manufactured either from wood or plastics and these would, therefore, disintegrate in a fire of any magnitude. Most of these radios are built on a rather heavy steel or aluminum chassis, and various components are often riveted to this metal base. A normal superheterodyne receiver will probably include a double-section variable capacitor having a rather heavy mounting. Carbon resistors or certain metal-encased capacitors may come through the fire reasonably intact. Parts of the clock are likely to be found.

Some similar components may be left behind if a purely electronic timer is involved. In this instance, a metal chassis may not be used, since amateur builders and experimenters often "bread-board" their layouts; that is, they build them on the surface of an ordinary piece of wood in order to speed construction and to hold costs to a minimum. In this case, the wood might burn completely and this would be advantageous to the arsonist. Resistors and capacitors would also be used in this type of circuit, although they would not be as well protected as they would be in a regular commercial unit. Parts of the relays might be in evidence, and the toggle switch may be expected to retain most of its original characteristics.

The big problem with regard to timers, besides their initial detection, lies in establishing proof that they were placed at a certain location for the express purpose of committing a crime.

VII. PROXIMITY DEVICES:

The characteristic symbol for a vacuum tube was displayed in figure 5-c, and the gas-filled type of tube was briefly discussed in the preceding section, but nothing has been said concerning the fundamental principle upon which such devices operate.

The simplest kind of vacuum tube consists of two elements. (Fig. 34)

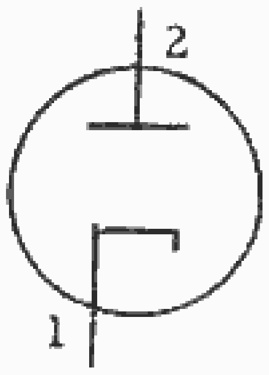


Figure 34.

The cathode, or the negative electrode, is shown in the illustration as pin number one; the plate, or the positive electrode, is indicated by pin number two. If a certain voltage is connected from pin one to pin two, no current will flow between the electrodes because they are not physically connected, and because the tube envelope is highly evacuated (in contrast to the gas-filled tube mentioned in the last chapter wherein the gas can ionize at a given electrical potential). Should the cathode of the tube be heated to a given temperature, however, the phenomena of thermionic emission takes place. Electrons are given off from the surface of the cathode, and a current of electricity then flows between the cathode and the plate.

When this manifestation was first discovered, it was regarded as something of a laboratory curiosity, until it was learned that the tube had the ability to accomplish rectification; i.e., the changing of an alternating current to a direct current. Consequently, modern diode rectifiers are still in use in large quantity.

Eventually, an additional feature made possible our present-day system of electronics. This is based on the essential physical axiom that unlike electrical charges attract one another, and like electrical charges repel one another. A third electrode, the control grid, is inserted between and at close proximity to both the cathode and the plate. (Fig. 35) The grid, being a sievelike affair much like a piece of screen wire, is found to exert control over the current flowing in the plate circuit of the tube as would an electrical valve. In fact, the English still refer to vacuum tubes by the graphic term "valve." If the cathode of the tube be operated at a negative potential, if the plate of the tube be operated.

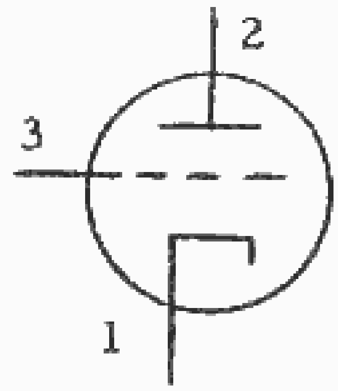


Figure 35.

at a positive potential, and if the grid be charged to a sufficient negative potential, then the electrons leaving the surface of the cathode will be repelled and will be prevented from reaching the plate. If, on the other hand, the grid is charged to a great enough positive potential with respect to the cathode, the flow of current between cathode and plate will be encouraged. Due to the construction of the tube, a tiny variation in the polarity of the charge on the grid can control a relatively large amount of current flowing between the cathode and the plate. The pattern of current flow in the plate circuit will be an enlarged copy of the current flow in the grid circuit. On this concept, electronic amplification by vaccum tube rests.

In reality, the operation of the vacuum tube is not quite so simple as it appears because of a number of limiting factors, but the basic principles by which they function may be put to work in the construction of proximity devices that are, in turn, very applicable to the initiation of electronic arson.

The term "proximity fuse" was well known during World War II., but this item was really a refinement of various mechanisms that had existed for years prior to that time. As the name implies, a proximity device performs its action when a person or a thing comes within a predetermined distance from the unit's sensing apparatus. The person or the thing may move toward the sensor, or as was the situation with the proximity-detonated projectile, the sensor may be moved toward the activating object.

One of the earliest of these devices was built around an oscillator, this being nothing more than an electronic amplifier arranged in such a way that part of the energy from the plate circuit is fed back into the grid circuit. This acts as an electrical "flywheel," and produces a more or less self-sustaining waveform of a type and of a frequency determined by the associated hookup.Oscillators can be built so that they are extremely sensitive to outside influences, and the trigger mechanism shown in figure 36 illustrates this perfectly.

This particular oscillator is constructed so that it is sensitive to changes in the capacitance of its tuned circuit. A Hartley-type oscillator is fitted with a capacitance detecting antenna attached to its grid (VI). This sensor may be a length of wire or a small plate of thin metal fastened to a door or to a window in the structure being "set up." Variations in this capacitance to ground, as effected by a person moving to within two to three feet of the sensor, will have the effect of changing the time-constant of the RC network R1 and C1. This will alter the amplitude of the oscillation. A portion of the oscillating voltage across the tuned circuit is rectified by the diode V2, and the output is filtered to become the control voltage applied to the grid of the relay tube V3. In short, if someone gets near the antenna of this unit, the relay will operate.

If such a device were used as a trigger for a "plant," and if it were installed in a business establishment at a propitious time, the arsonist would have ample time to travel to some distance before the event took place. If a business were closed for the weekend, initiation would probably not occur prematurely. With the resumption of regular activities at the start of the week however, someone would eventually come to a door or a window, and when they did, disaster! An interesting sidelight to this method would be the undisputed fact that the arsonist would not know when the crime actually occurred.

It is not absolutely necessary that an oscillatory circuit be used to achieve this net effect. The wiring diagram in figure 37 shows a hookup whose action is similar to that of the capacitance operated relay, but yet functions by an entirely different agency.

The integral wiring in most buildings tends to radiate a rather strong electromagnetic field. This is not directly evident to the inhabitants, but is sometimes manifested in hum in a radio or by electrical disturbances in a nearby television or hi-fi set. It is also a known and easily demonstrable fact that the human body is quite an efficient receiving antenna. This may be illustrated by grasping the antenna connector of a radio set and noticing the increase in signal strength that results.

Our old friend the thyratron tube appears in this circuit. Arrangements are made through the resistance network attached to the control grid of the tube so that a negative charge of sufficient magnitude is normally present to prevent current flow between cathode and plate. When a human body approaches the sensing unit, in this case a thin metal plate, electromagnetic radiations from the wiring in the building are picked up by the body and impressed, in addition to the normal negative charge, on the grid of the tube. Since this radiated field is alternating by nature, the grid swings alternately from positive to negative. When the grid is made sufficiently positive by the close proximity of the human body, the tube achieves a state of conduction, current flows through the plate circuit of the tube and hence through the activating coil of the relay, and the relay operates. A variable resistor, R3, is provided so that the threshold at which the device oper-

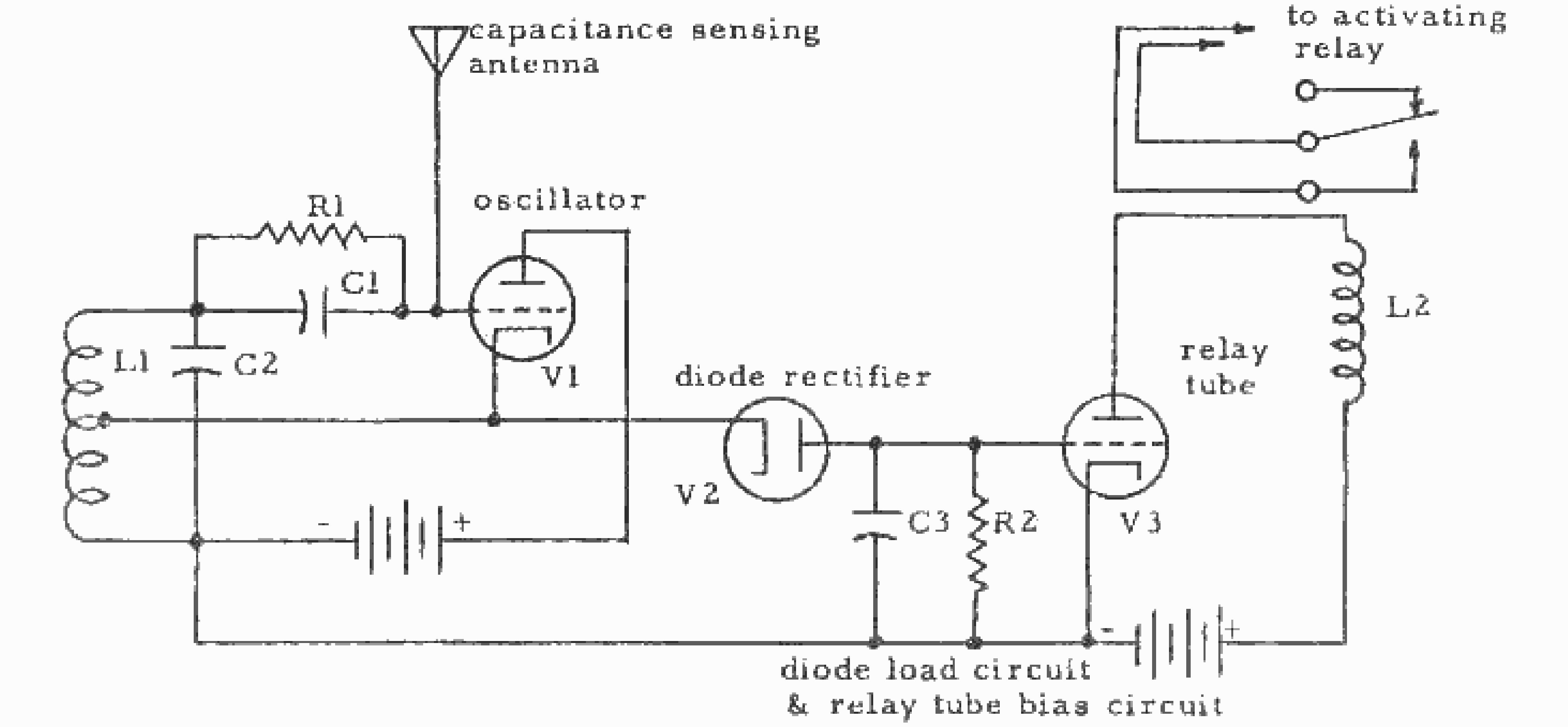


Figure 36

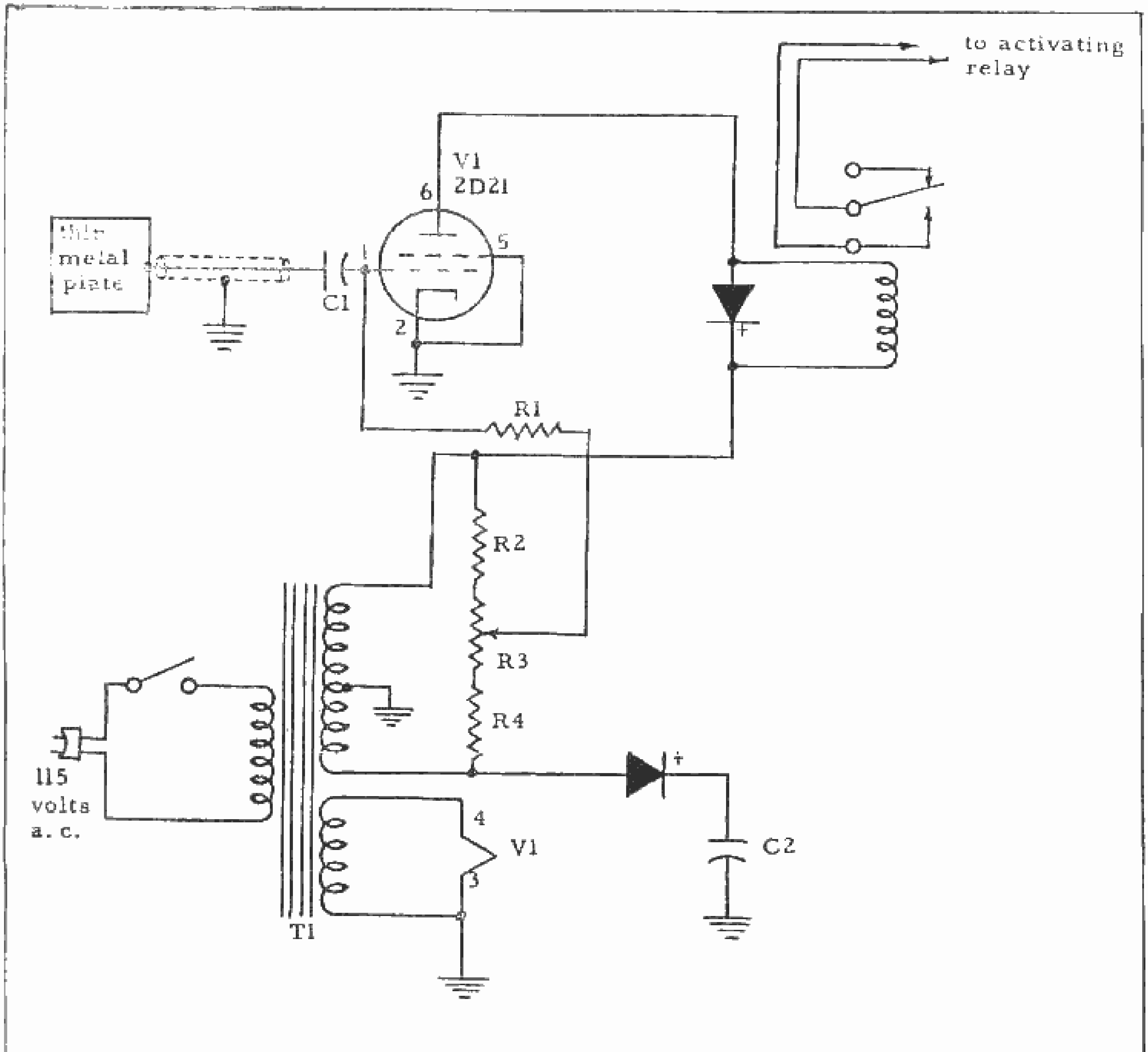


Figure 37.

ates may be readily altered.

If the cause of the fire or an explosion is not apparent, if the use of electronics in the initiation of the occurrence is suspected, and if the beginning of the fire or the detonation of an explosion coincides with the presence of a witness near a door or a window of the structure destroyed, look for a device of this nature.

Being electronic, the usual remains may be found in the debris; resistors, capacitors, relay parts, chassis, etc. In a unit operated by alternating current as shown in figure 37, the power transformer, T1, may be discernible. These components are often enclosed in steel cases, and usually have laminated cores of heavy steel. The core, if all the wiring is removed, will look something like this. (Fig. 38)

Vestiges of the sensing antennae may be left behind. These devices will work well even through a pane of glass of ordinary thickness, therefore, it is considered permissible practice to cement the metal plate or strips used for sensing directly to the inside of a glass window or door. Care should be exercised that such a sensor is not confused with a legitimate burglar alarm that often makes use of foil strips on the inside of a door or window in providing its needed protection. Thin wire sensing antennae are sometimes stapled to the surface of the door or window's framework.

VIII. PHOTOELECTRIC DEVICES:

Changes in light intensity provide a ready means of triggering a fire or an explosion, and may be considered from two diametrically opposed viewpoints. Associated circuitry can be so contrived that the photoelectric system will function by virtue of the sudden or the gradual exclusion of light or, conversely, by the sudden or the gradual addition of light. Units of this nature may also be set to operate at a specific light intensity.

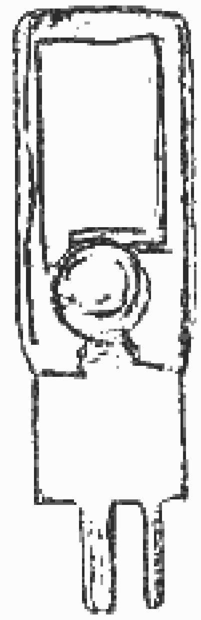


Figure 39.

All photoelectric components now in use fall within three broad classifications either as to their representative structure, or as to their mode of application:

a. Photoemissive
b. Photovoltaic

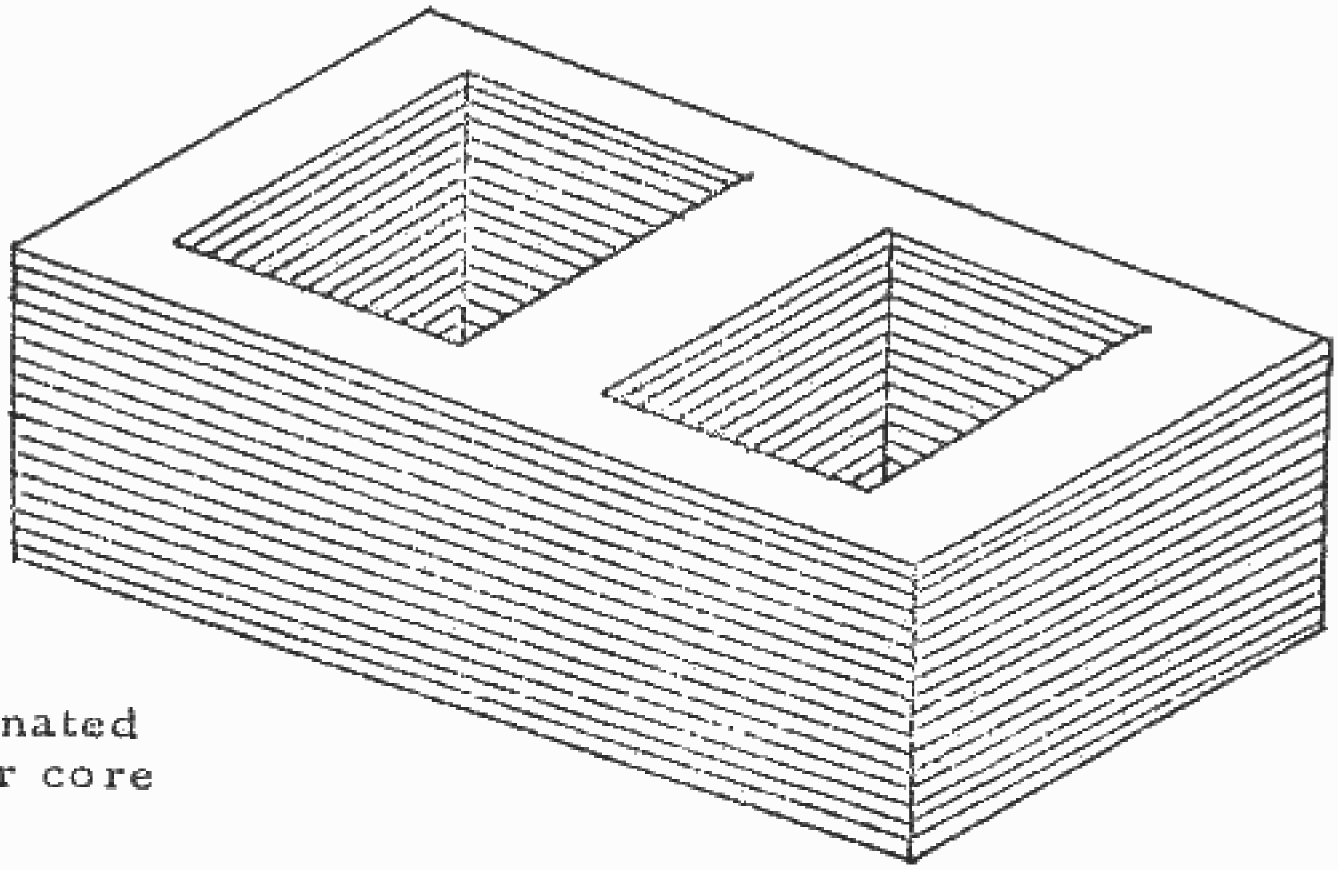


Figure 38.

c. Photoconductive

The oldest of these, and also the type in greatest use is the *photoemissive* cell. (Fig.39) In form, these instrumentalities are true vacuum tubes, although they are sometimes gas-filled in order to enhance the amount of emission. Like the conventional vacuum tube, they exhibit the capability of internal emission, but of a decidedly different character. A voltage impressed across the two elements of the tube will not cause a current of electricity to flow between the electrodes because of a lack of connection and because of the highly evacuated interior of the tube. In the ordinary vacuum tube, emission takes place by thermal initiation; in the phototube, emission is begun and sustained by ambient light impinging on the photocathode of the tube. The current flowing through the tube is a product of the total radiant flux falling upon the cathode and the luminous sensitivity of the cathode. The actual current derived from this action is proportional to the illumination in foot-candles, the unit-candle or candlepower being an arbitrary standard of luminous intensity, and the foot-candle being the normal incident illumination produced by a one candlepower lamp at a distance of one foot.

Since the phototube displays an inherent high impedance, it is readily adaptable for coupling with the input of a vacuum tube amplifier as shown in figure 40. The 6F5 tube in the illustration is biased to "cut-off"(will not conduct) until light falling upon the photocathode of the 919 tube begins to alter this condition. When a sufficient amount of light is present, a current flows through the tube, and the grid of the 6F5 swings toward a positive polarity. When the grid becomes positive enough, the tube conducts, the 25A6 tube is

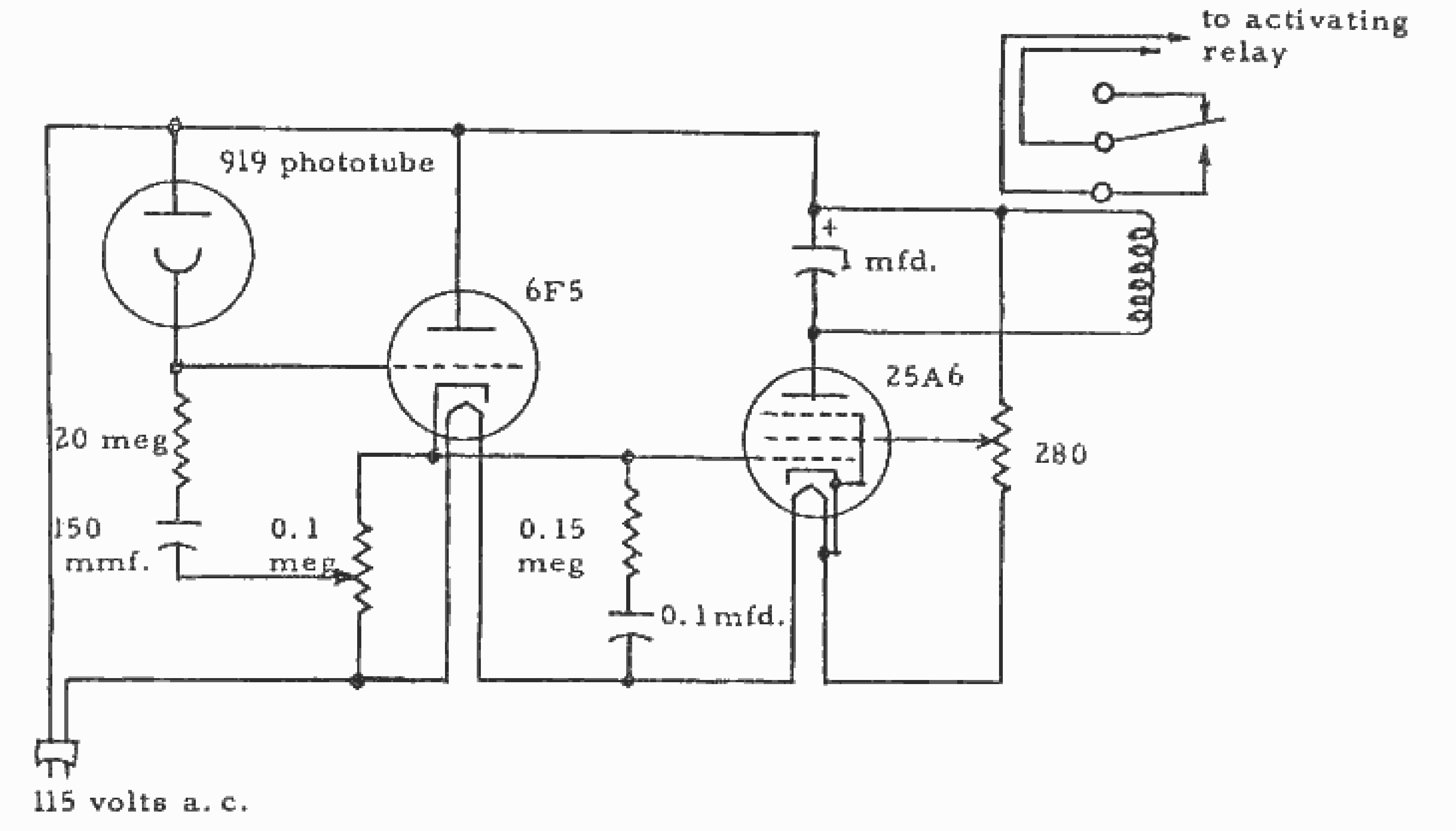


Figure 40.

triggered, and the relay operates.

This kind of photoelectric relay is quite sensitive, and will perform with a light pulse as brief as 1/60th of a second in duration. Placement at a crime site must be accomplished with discretion, since the light of a passing vehicle might cause initiation at the wrong time.

The *photovoltaic* devices are the most modern. They are semi-conductor or, in other words, "solid-state" components, and they incorporate the principle of the conversion of radiant energy directly into usable electrical power. The photovoltaic phenomenon is founded upon the basic photoelectric equation of Albert Einstein, namely:

$$\frac{mv^2}{2} = hf - W$$

which states that the electrical energy of the photoelectrically excited electron is proportional (by Planck's constant h) to the frequency of the impinging radiant energy. W is the work function or the energy necessary to free the electron from its bonds in the atom. Being solid-state, these units have no glass envelope and hence, no vacuum. They are rugged in the extreme, and will continue to operate in temperatures ranging from minus 195 degrees to plus 100 degrees Centigrade. They are also very tiny. Figure 41 depicts a typical photovoltaic cell in its actual size.

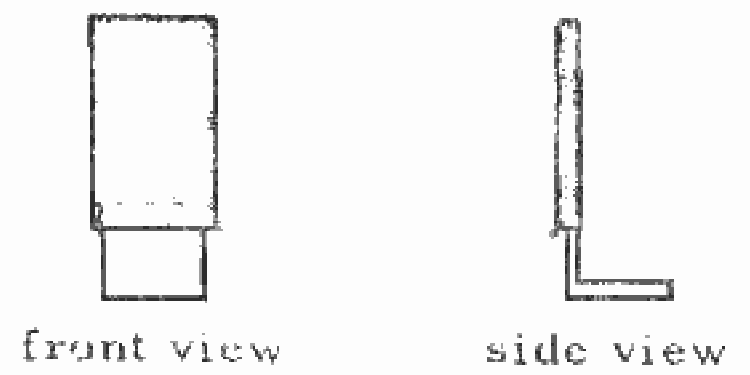


Figure 41.

This amazingly small physical size, together with husky and simple construction, makes these components absolutely ideal as a trigger

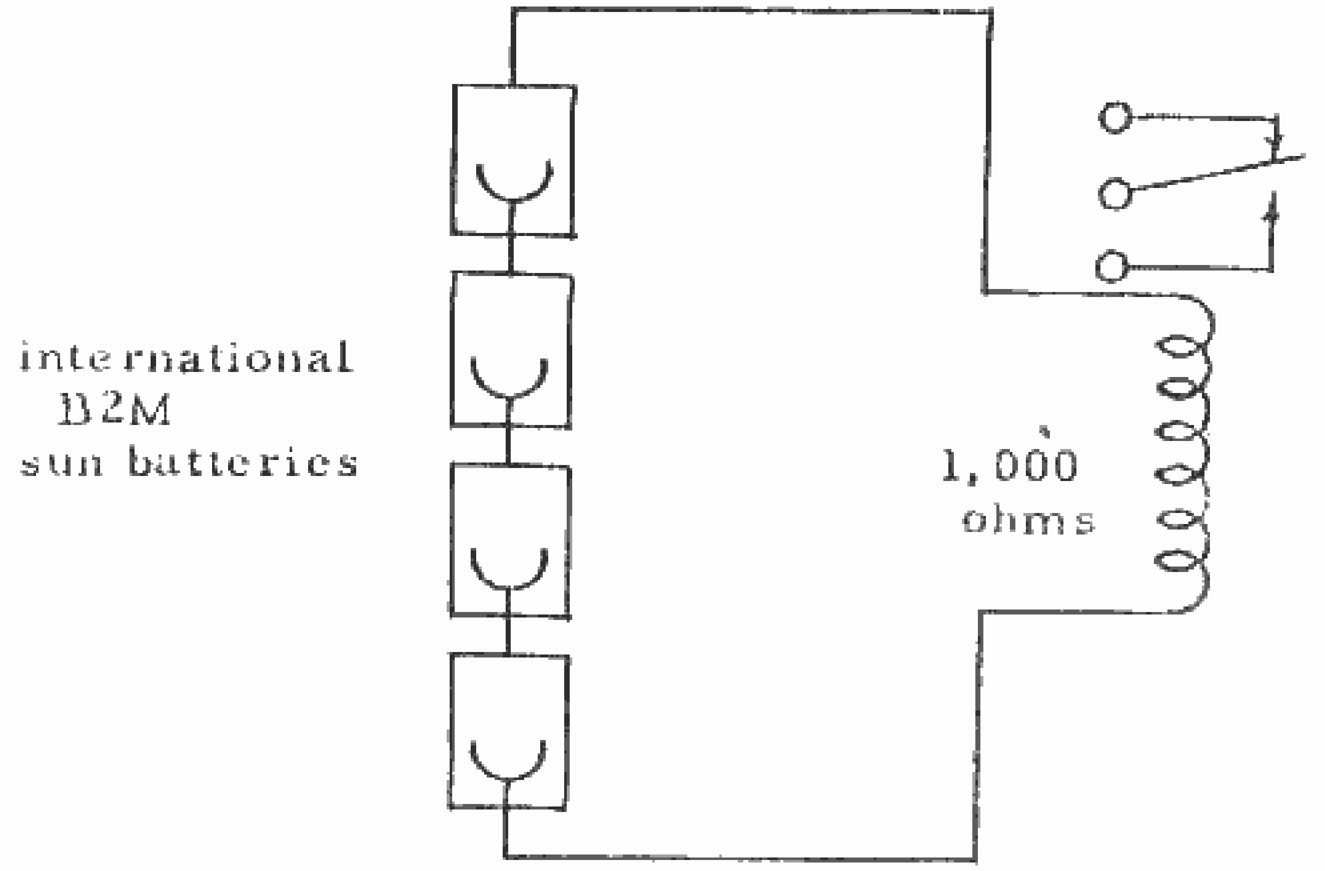


Figure 42.

for electronic arson. They do not even need an external source of electricity. The straightforward configuration of an operating circuit using this device is shown in figure 42.

From an electrical viewpoint, nothing could be less complicated. Light falls upon the surface of the photovoltaic cells, a current of electricity is generated by them, and the relay operates because of the current passing through its actuating coil. Little imagination is required to see that this kind of a circuit could trigger a fire or an explosion and remain relatively unobserved after the fire. This circuit will fulfill its particular service with large excursions in light level, but it is not too sensitive.

This problem of sensitivity is easily overcome by using a similar cell as a *photoconductive* device. How this is done is shown in figure 43.

If a small voltage is instituted across a series of these photocells, little current will flow through them until they are exposed to light. When light does impinge upon their surface, they begin to operate exactly like a "light-operated-valve"; the greater the amount of light falling on the cell, the greater the current that flows through the cell. The maximum current, or course is subject to the physical and constructional limitations of the individual cell. This type of application increases the apparent sensitivity from one and one-half to ten times, this particular device operating at a light level of about 50 foot-candles.

Figure 44 illustrates a method of combining the solid-state photoconductive cell with a thyratron tube in order to achieve an even greater sensitivity.

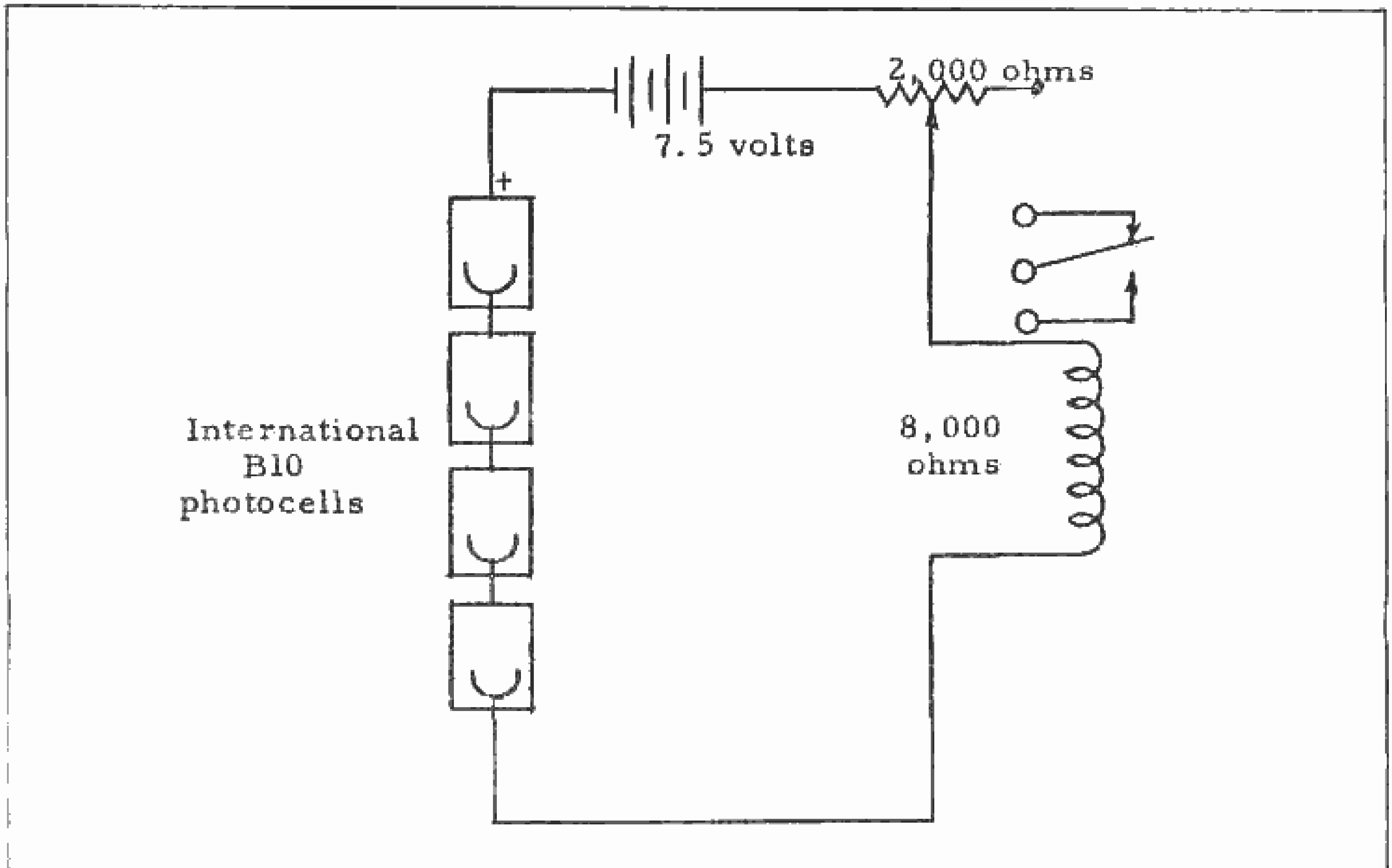


Figure 43

The type 6012 xenon-filled thyratron is normally in a non-conducting state. When light falls on the photoconductive cells, the control grid of the tube begins to go more and more positive as the current through the cells increases. Finally, a state of conduction is acquired within the thyratron, and the relay operates. This circuit falls into the grouping known as ultra-sensitive because of the fact that it will perform with the presence of one-half of one foot-candle of light.

Any of these circuits will function through variations in the ambient light level in a structure or through variations in the intensity of a sharply defined and restricted artificial light source. They may be readily implemented into a trigger mechanism by the expedient of placing them in an exposed position on the exterior of the building being prepared. If the device to be activated were connected to the bottom set of relay contacts, the rising of the sun and the consequent rise of the outside illumination to a certain critical level would accomplish the desired result through the closing of the relay. If the device to be activated were connected to the top pair of relay contacts, a different sequence would be followed. The relay must, in this case, first be energized by exposing the sun batteries to high illumination. While the relay remains closed, final connections are made. When the sun sets, the outside illumination begins to fall. When it declines to the necessary intensity, the relay opens and the "plant" is set off.

The photocell might be adjusted to trigger the relay when a street light is turned on; it could be hidden behind a small hole in an opaque surface so that it would trigger at a

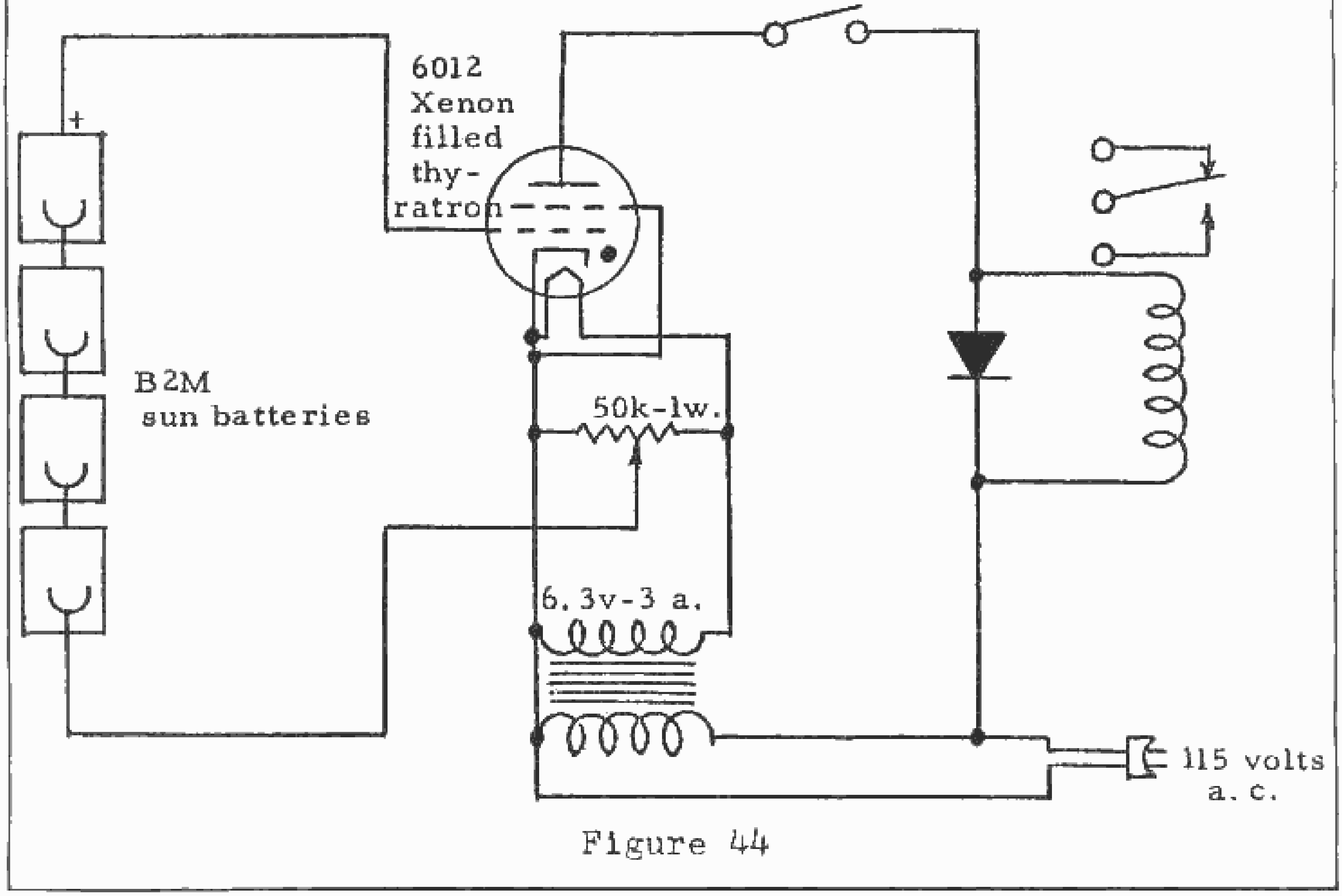


Figure 44

definite position of the sun; a pilot light on an instrument panel or on a telephone switchboard could operate it. The applications are absolutely innumerable.

Look for these devices if the cause of the origination of a fire or an explosion is undetermined, and if the event occurs at sunrise or at sunset. If a light source other than the sun is utilized, any other correlating time-factors will be most dubious and obscure. If solid-state components are used, little will be found in the ashes except possibly the small metal bracket on which they are formed. If vacuum tubes are used, the usual remains associated with an electronic chassis may be anticipated.

IX. SOUND OPERATED DEVICES:

One of the basic tenets of the science of physics has to do with the transducer. Evolving from the Latin word *transducere*, meaning literally "to lead across," it comprehends devices actuated by power from one system and supplying power to another system. If this sounds somewhat esoteric and abstract, consider the fact that the familiar microphone and the common loudspeaker are both members of this species.

The specialized function of this kind of transducer is most vital. Electronic circuits cannot amplify or otherwise process sound energy per se; in the jargon of the technician, "piping sound into a room" does not mean sending it through a water pipe. Sound energy must first be transformed into a corresponding pattern of electrical energy that *can* be processed by electronic means and then, as in the art of broadcasting, must be reconverted back into sound energy encompassed in a band of frequencies that can be perceived by the human sense organs.

The transmission of sound through the air actually consists of an alternate compression and rarifaction of the molecular structure of the air itself. When this wave-like movement

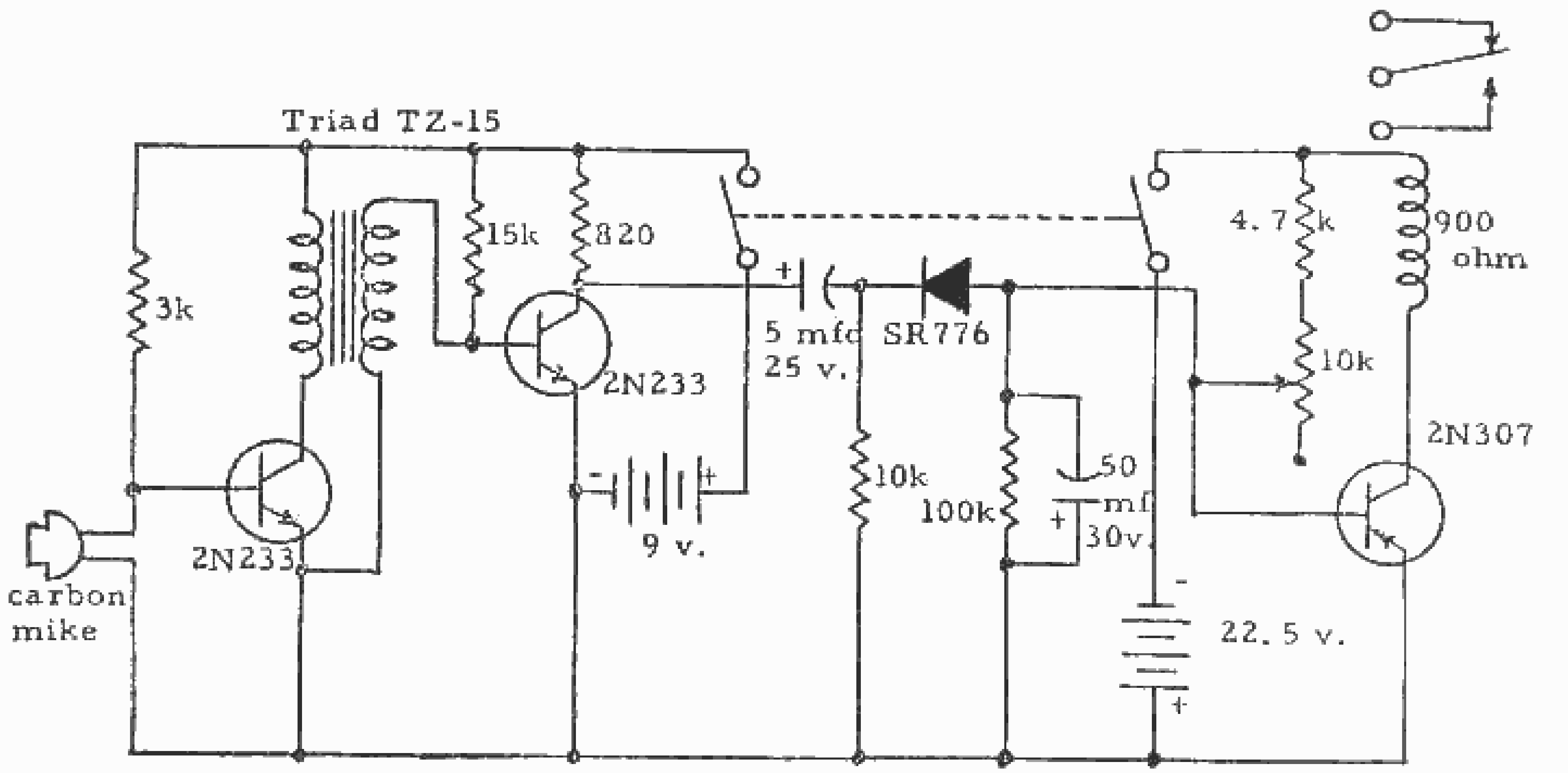


Figure 45.

intrudes upon the tympanic membrane of the human ear, or upon the flexible diaphragm of a microphone, mechanical movement is exchanged with that medium.

In one much-used type of microphone, a small movable coil of wire is attached to the diaphragm, and the coil placed in close juxtaposition to a permanent magnet. When sound waves agitate the diaphragm, it moves; the coil, being linked to it, also moves and in so doing, cuts lines of force emanating from the magnet. The end product is a feeble current of newly generated electricity whose intrinsic pattern is characteristic of the particular sound involved. This minute current, generated by and now bearing the image of its progenitor, may be then passed along to an electronic amplifier or to some other similar device.

Once the sound energy has been converted to electrical impulses, it is not mandatory that the reverse process be carried out. In figure 45, the net result is the mechanical movement of a relay.

Transistors have been used in this hookup, so that the power requirements would be minimal, and so that the size of the completed unit could be sharply reduced. A carbon microphone is used as a transducer. Here, the movement of the instrument's diaphragm alternately compresses and releases pressure on carbon granules within the body of the microphone. This has the effect of regulating the flow of direct current through the microphone. The ensuing electrical pattern, now referred to as the modulated direct current, is amplified by the first transistorized stage, and coupled to the second stage of amplification through the transformer. The output of the second stage is rectified by the diode, and the rectified current is used to control the third transistor. When a loud enough sound level reaches the microphone, a critical operating point is realized in the third stage; the transistor conducts, and the relay closes. The 10,000 ohm variable resistor makes it possible to pre-select the sound level at which the relay will move.

Incorporation of this kind of a unit into an arson or into a criminal explosion creates a new set of problems for the law enforcement agencies. Such a device may be wired to a "plant," and the microphone placed near a telephone. If this is done at the beginning of a weekend or during the first day of a holiday period, the prepared building would remain uninhabited long enough for the criminal to travel to a great distance before making the long-distance telephone call that would initiate the actual crime. This unit would function just as well in the vicinity of a railroad, an airport, or in any situation where the existence of a high noise level could be predicted.

Another similar appearing device will carry out the long distance 'phone call gambit but with a slightly different twist. If two electrical conductors are laid side by side, and if a current of electricity is passed through one of the conductors, a sympathetic or *induced* current is found to flow through the second or unconnected wire. In figure 46, induction is the source of our ultimate control impulse.

An inductive device, popularly known as a telephone pickup coil, and originally designed for the recording of telephone conversation, is wired to the first stage of amplification in an electronic hookup whose action is almost the same as that of the circuit shown in figure 45. The pickup coil is placed under any convenient telephone. When the impulse necessary to ring the bell flows through the instrument, a current is induced in the pickup coil. This resulting signal, after further processing, culminates in the closing of the relay.

As modern communications technology advances, it will become more difficult to detect this kind of trigger mechanism. In some instances, if a voice-operated or inductive device is suspected, inquiries can be conducted to determine whether or not a long distance call was made to the telephone number in question at the time when the crime was alleged to have taken place. With the increase in the use of automatic equipment, the advent of direct distance dialing from one city to another, this procedure will not always prove to be fruitful.

Such units will usually be found in close proximity to a telephone, but in some applications of the sound operated relay, this may not be true. The circuitry is miniaturized for the most part, and the remains will be difficult to spot after a disaster. Aside from the conventional electronic debris that might be expected, look for a metal shell of a microphone, or for the inductive loop that may have been protected from destruction by being hidden under the telephone.

X. TEMPERATURE AND MOISTURE OPERATED DEVICES:

Temperature excursions and even seemingly innocuous variations in the moisture content of the atmosphere can trigger an arson or an explosion with devastating efficiency. Admittedly, this comprises a somewhat subtle approach to the problem but, of course, to the criminal mind, obscurity of intent and cyrptogrammatic methods are highly desirable.

One of the most common means employed to sense changes in temperature is not electronic at all, but rather electro-mechanical. It is a well known physical manifestation that most solids expand with the application of heat, and contract with the application of cold. This medium is predicated upon the fact that different solids do this expanding and contracting at disparate rates. This may be expressed as a coefficient of linear expansion per degree of temperature change. Three of the most used metals exhibit the following expansion coefficients per degree Fahrenheit:

aluminum	.000014
brass	.000011
copper	.000009

Should strips of two of these dissimilar metals be tightly riveted together, and should

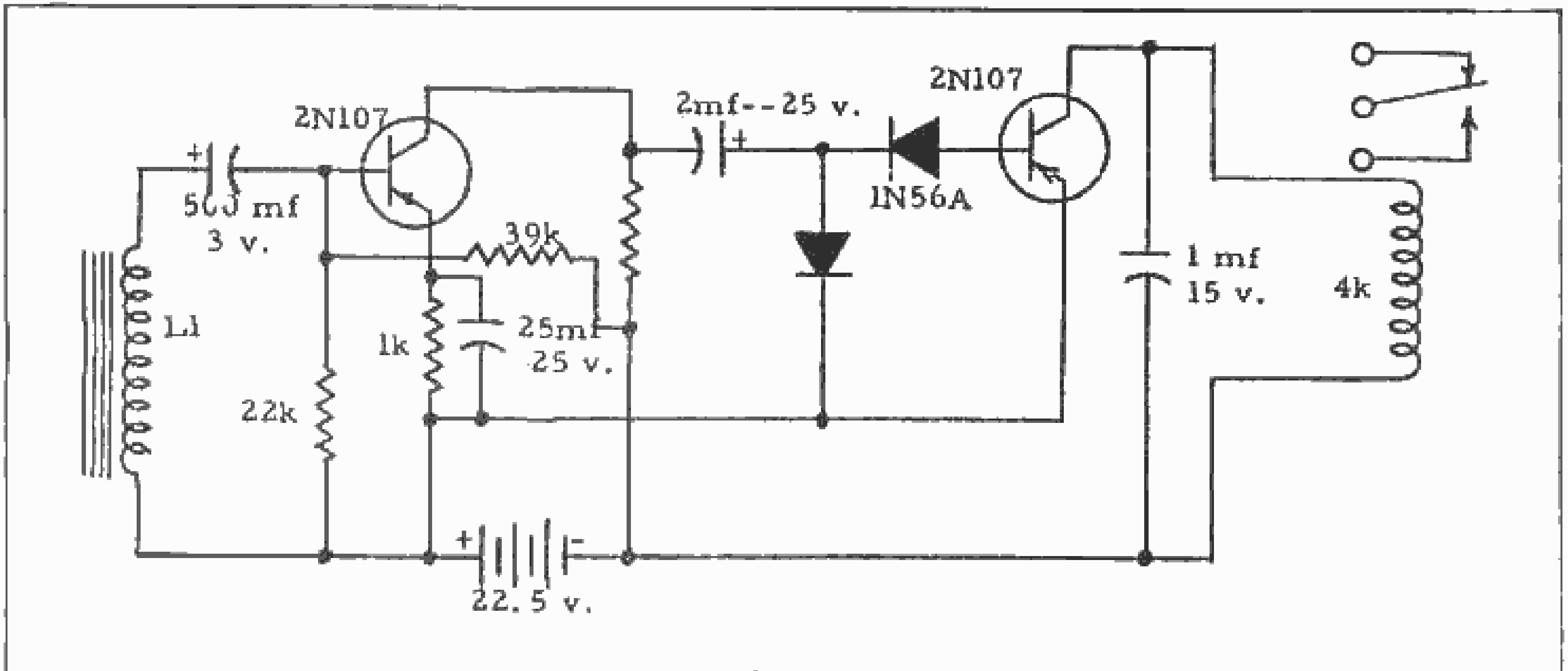


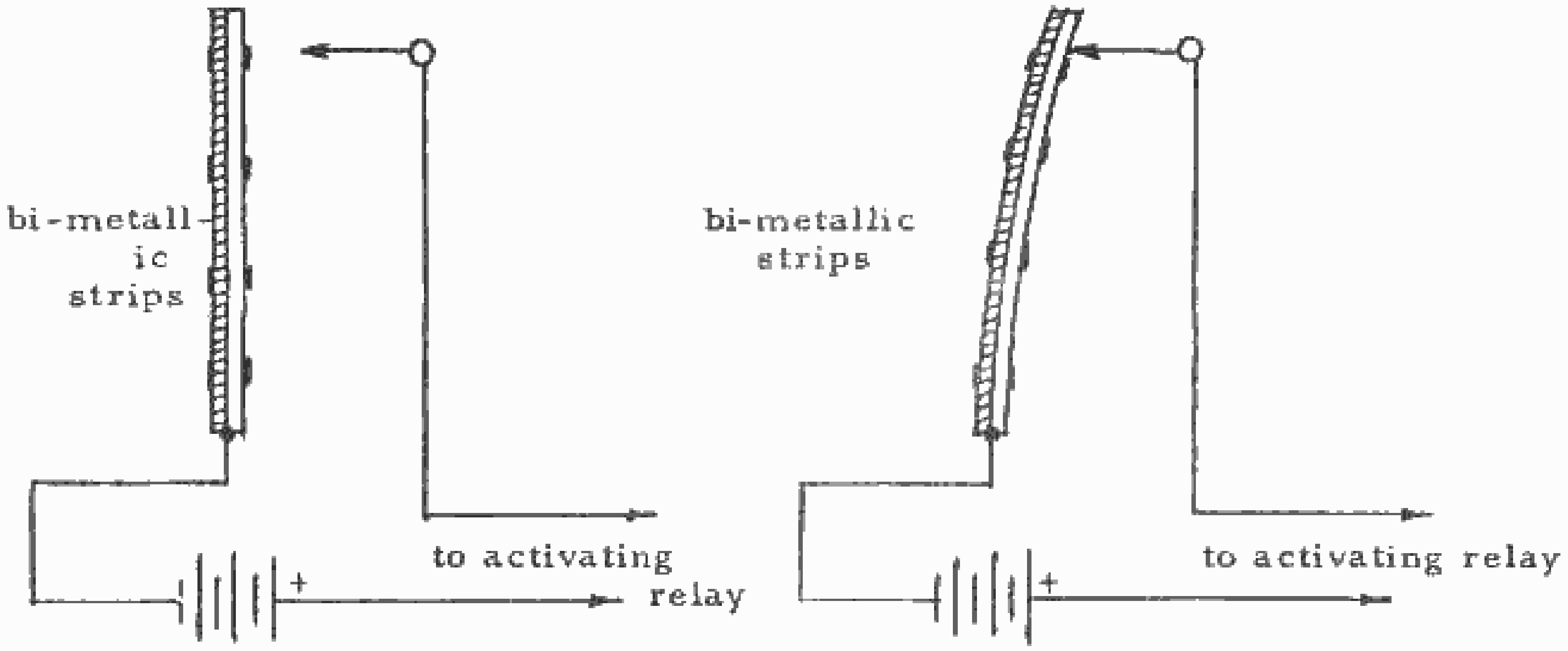
Figure 46.

heat or cold be applied to the resulting "sandwich," either expansion or contraction will follow. Since the metals do not possess the same expansion coefficients, stresses will be set up and deflection will be the end product. This effect can be utilized as a trigger device with little difficulty. This conformation makes up the everyday thermostat that is to be found in many electrical devices within the home and business establishment. A quick perusal of figure 47 will show how the temperature-induced bending of the bi-metallic element completes a circuit which operates the activating relay.

The same thing can be done with a circuit that embodies pure electronics. All transistors are characterized by a certain amount of leakage current which varies directly, within some fixed temperature limits, with the heat applied. In figure 48, the transistor's accompanying wiring is arranged so that little current flows through the relay coil. When enough heat is applied, however, the current flow through the transistor increases by a proportional amount and finally, the relay closes. By adjusting the circuit so that the relay remains in a closed position at a given heat level, and by using the top pair of relay contacts, the device can be made to trigger a "plant" with a decrease in temperature.

Installation of these units will be very unobtrusive. Look for them near a furnace or a heating duct in a home, or adjacent to a furnace or an oven in an industrial plant.

Various hygrometric or moisture-sensing units are on the present day market. Many of them are of comparable size and shape to the one depicted in figure 49, although their uses are widely divergent. When used as the controlling component in an electronic circuit, they can automatically raise the top of a convertible or close a car window if rain threatens. They can notify parents when a child is incontinent during sleep (under the hideously "cute" trade name of "wee-alarm"). They can telemeter the moisture content of the upper atmosphere to people on the ground. They can trigger an arson.



a. before application of heat or cold

b. after application of heat or cold

Figure 47.

If a ready explanation of a crime does not present itself, consider the existence of one of these little gems, especially if the incident occurs during a period of high humidity or at the beginning of a rain.

XI. IGNITION OR DETONATION BY RADIO

In describing the varied electronic circuitry in the preceding pages of this treatise, operation has been explained as a function of the movement of electricity through wires. Not touched upon is the somewhat surprising concept of electrical currents that cannot be confined to a wire, and this idea is the basis for the piece de resistance of electronic arson; namely, the activation of a device by remote control, from a distance, and without the use of connecting wires.

It has become a conventional practice to speak of the electricity used within the home as coming from a 110 volt service or from a 220 volt service. The assignation of a definite value to this voltage seems to imply that its magnitude is constant. However, these maximum potentials are realized for only a small percentage of the total time, the actual value constantly rising and falling, due to the fact that the current is of an alternating nature. Figure 50 illustrates this fundamental relationship. Practically all of the electricity in the homes in the United States is supplied at a frequency of 60 cycles per second. At the start of a cycle (the left hand extreme on the zero axis) in figure 50, the voltage is at zero and rises rapidly with time to its maximum potential on the positive side of the zero axis.

At this point, its value declines swiftly to zero again, and the potential begins a quick rise to maximum on the negative side of the zero axis. The fall of the potential to the zero axis once again completes one cycle. In the case of 60 cycle current, this takes place in 1/60th of a second.

If this electrical current is passed through a wire, it can be shown that the wire is sur-

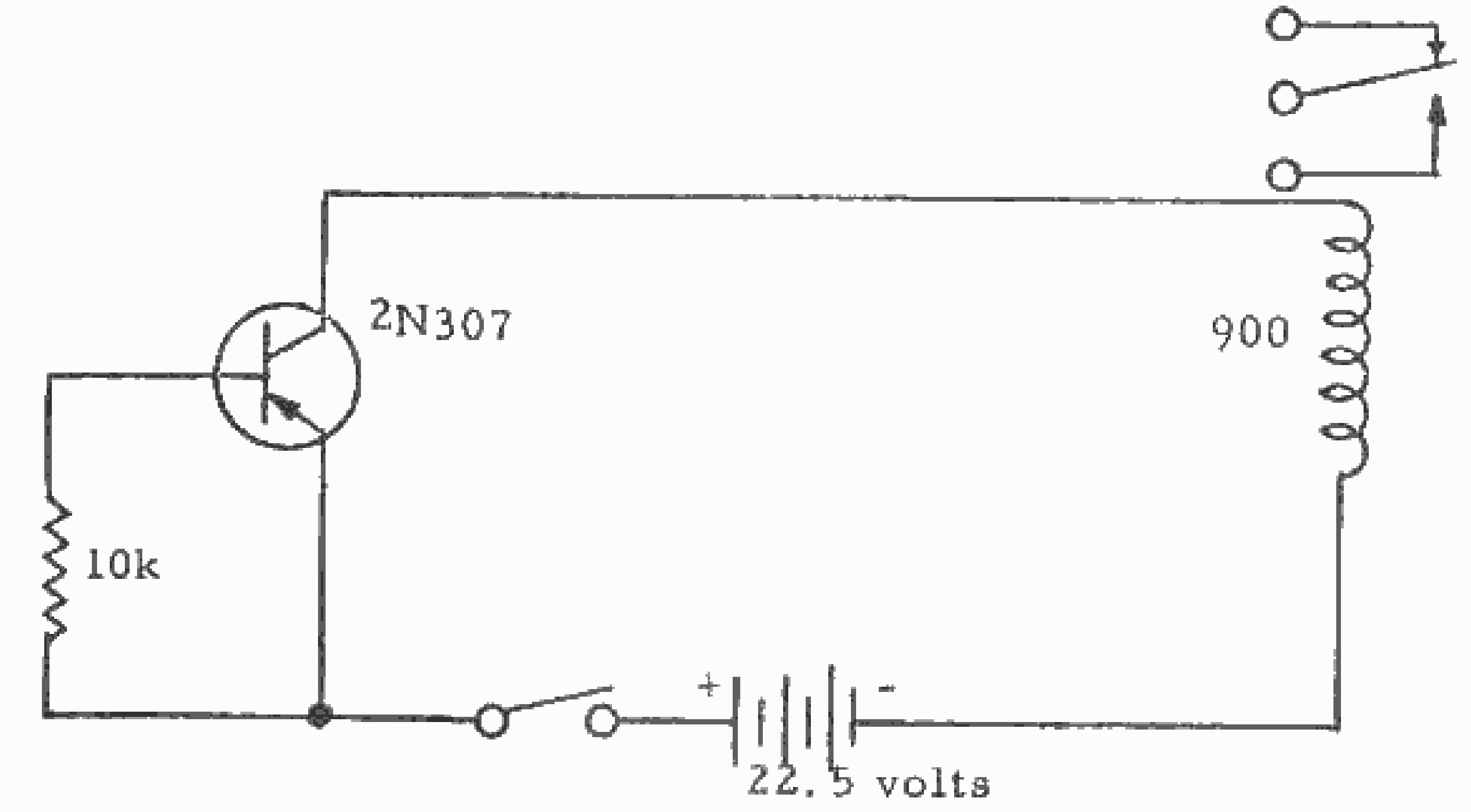


Figure 48.

about one-half
actual size

Figure 49.

rounded by an electromagnetic field set up by the current. Furthermore, the field is alternately expanding and collapsing at a speed corresponding to the frequency of the alternating current. (Fig. 51)

This is quite an ordinary physical phenomenon that forms the foundation for many electrical and electronic devices; a phenomenon that takes on an added and vital significance if one change is made.

It can be demonstrated in the laboratory that the expansion and the collapse of such an electromagnetic field requires a finite amount of time. If the frequency is raised to a certain rate so that the collapse of one field cannot be completed before the expansion of another cycle's field begins, the electrical energy cannot be confined to the conductor and will push out all directions much like the ripples in a pond resulting from a thrown rock. This is termed *radio-frequency energy*, and makes practical all broadcasting as we know it.

The generation, transmission and reception of radio frequency, or RF, energy can give rise to all sorts of complicated computations and special considerations of physical laws and principles, but on the surface, the general procedure looks very easy. (Fig. 52) RF energy is generated in a transmitter of some type and is coupled to an antenna. The resultant waves spread out from the antenna and eventually arrive at a receiving antenna. This is attached to a receiver whose circuitry is sensitive or resonant to the particular fre-

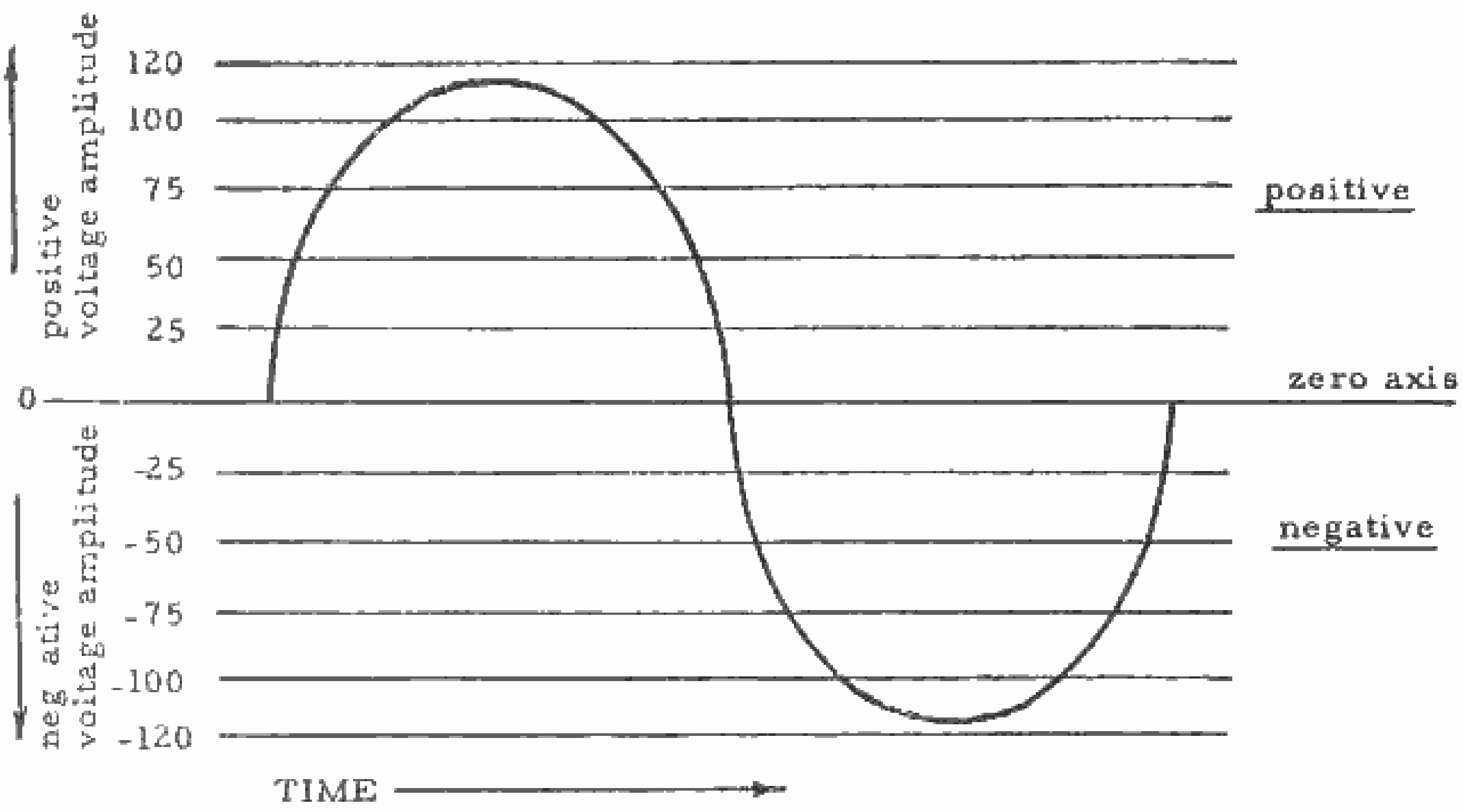


Figure 50.

quency being transmitted. Further wiring within the receiver converts this energy to audible sound or, as desired in a trigger mechanism, into the movement of a relay.

Before radio-controlled apparatus can be employed, several important questions must be answered:

1. From what distance is the device to be triggered?
2. How powerful must the transmitter be?
3. What kinds of transmitting and receiving antennae are necessary?
4. What kind of receiver must be utilized?

Unfortunately, there are no hard and fast answers to these questions; answers that will give one hundred percent reliability at all times. This makes the use of radio control just a little ticklish under certain conditions. For example, the tiny transmitter shown in figure 53 was originally designed to open a garage door at close range.

It was intended to be used with the relatively insensitive receiver in figure 54.

When attached to a short antenna, it will do its job admirably, and will not be accidentally operated by some other radio transmitter, primarily because of the insensitivity of the receiver and because it is not capable of perceiving signals except on a fixed frequency. On the other hand, if the output of this small transmitter is fed into a larger antenna or an antenna with directive characteristics, and if the receiver is made more sensitive, longer range operation is possible. Any "ham" will confirm the fact that under certain conditions, a few watts of RF power can be heard, literally, around the world.

The necessity for low receiver sensitivity to guard against accidental operation by an unwanted signal can be obviated by superimposing intelligence on the primary RF energy (modulation), by coding this intelligence, and by providing the receiver with circuits responsive only to this exact code. Receiver sensitivity can be increased to an amazing point where the most infintessimal signal can be picked up and used.

Commercial garage door openers are readily obtainable and can be modified to give the de-

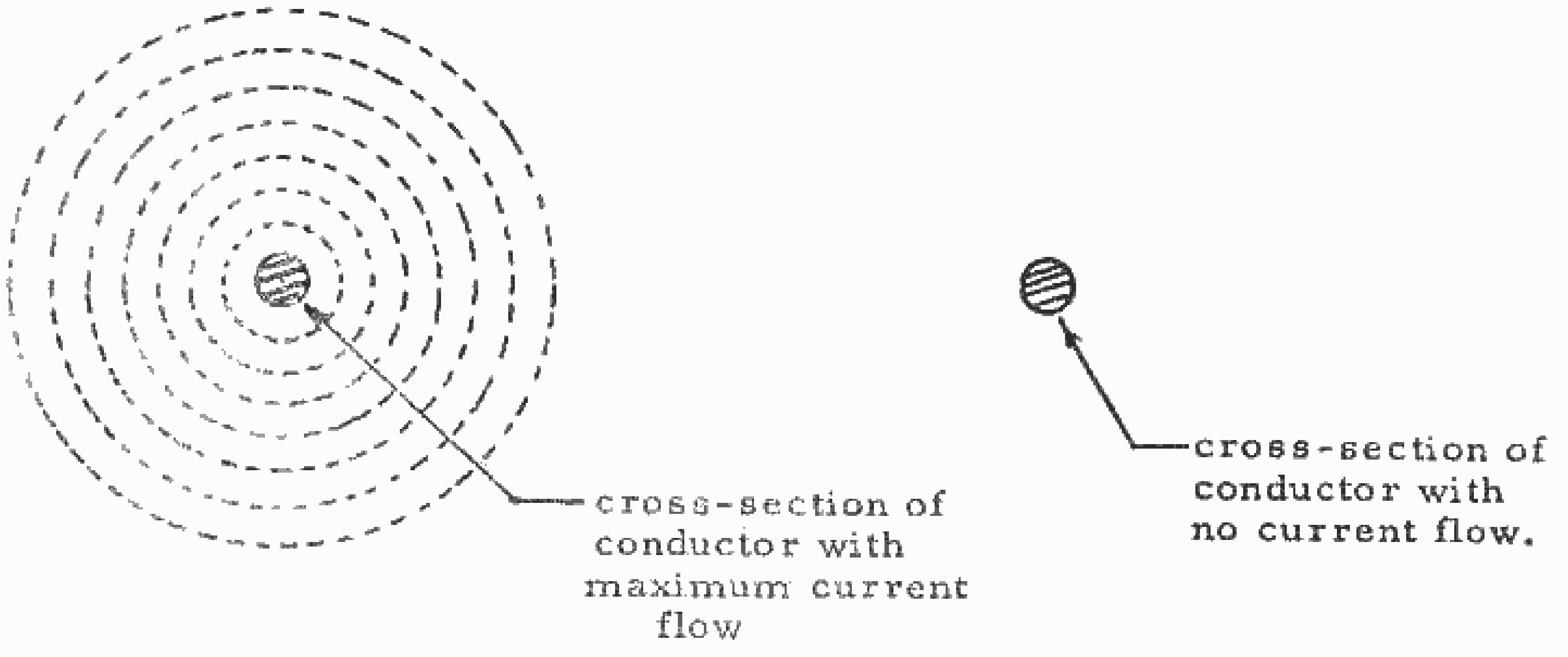

cross-section of conductor with maximum current flow
cross-section of conductor with no current flow.

Figure 51.

sired results without too much trouble. There are also many devices for sale that were built for the purpose of radio controlling model ships and airplanes. These units usually have a somewhat longer normal range of operation, and many of them are coded in some way to permit control of a number of individual circuits through one transmitter.

Range of performance can be increased by raising the power of the transmitter. Amateur transmitters in powers up to 1,000 watts can be bought from a number of retail and wholesale outlets. A skilled electronics technician can build a comparable instrument without any great effort.

In short, the use of radio control will necessitate some knowledge, care and experimentation, but the results will probably be worth the trouble to an advanced arsonist. This method is not for beginners.

It is doubtful that a transmitter used in this context can ever be discovered except through the voluntary surrender by the user. The unit could be located anywhere, and because only a brief pulse would be needed to initiate the crime, standard direction finding techniques would be useless. The size and the use of all transmitting apparatus is closely regulated by federal law, but these limitations would not disturb the criminal. Of course, should he be convicted of arson, and should it be proved that he initiated the crime by the use of an illegal radio transmitter, an additional federal charge can be instituted against him.

It is very possible that remains of the receiver could be discovered in the fire residue. The antenna might be in evidence. Remember that the innocent appearing television antenna could be used as a highly directional and efficient antenna for this kind of reception.

XII. SUMMATION:

Here, then, is an exposition of some of the ways in which electronics can be subverted to criminal purposes. There will be those readers who agree that this new field comprises a present and a growing threat that must be faced and dealt with by law enforcement agencies. There will be those who laugh in derision and hurl the handy slur of "Rube Goldberg devices." But bear in mind that although most of the hookups proposed by the beloved Rube fulfilled their functions in a jesting way,

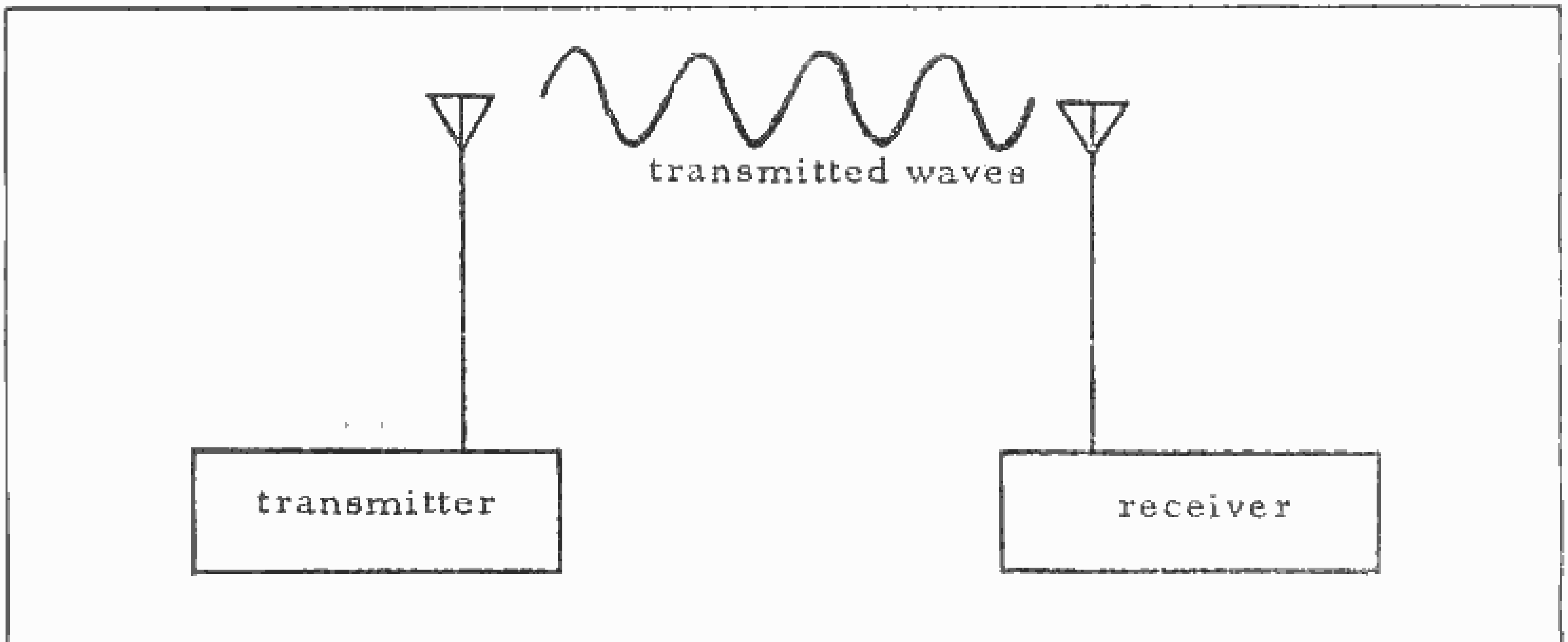


Figure 52.

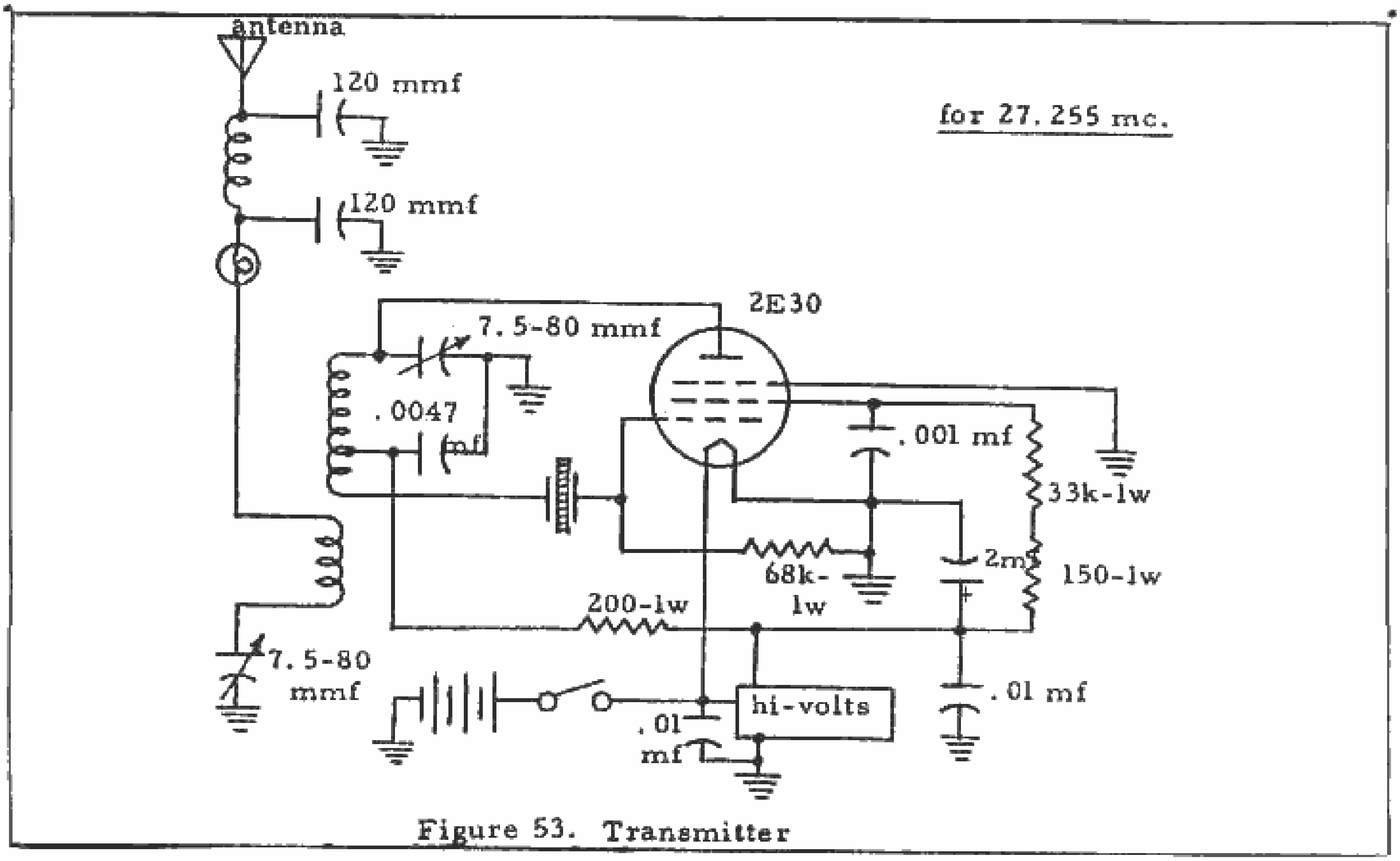

antenna
120 mmf
120 mmf
for 27.255 mc.
2E30
7.5-80 mmf
.0047
mf
.001 mf
33k-1w
68k-
1w
2m
150-1w
200-1w
7.5-80
mmf
hi-volts
.01
mf
.01 mf

Figure 53. Transmitter

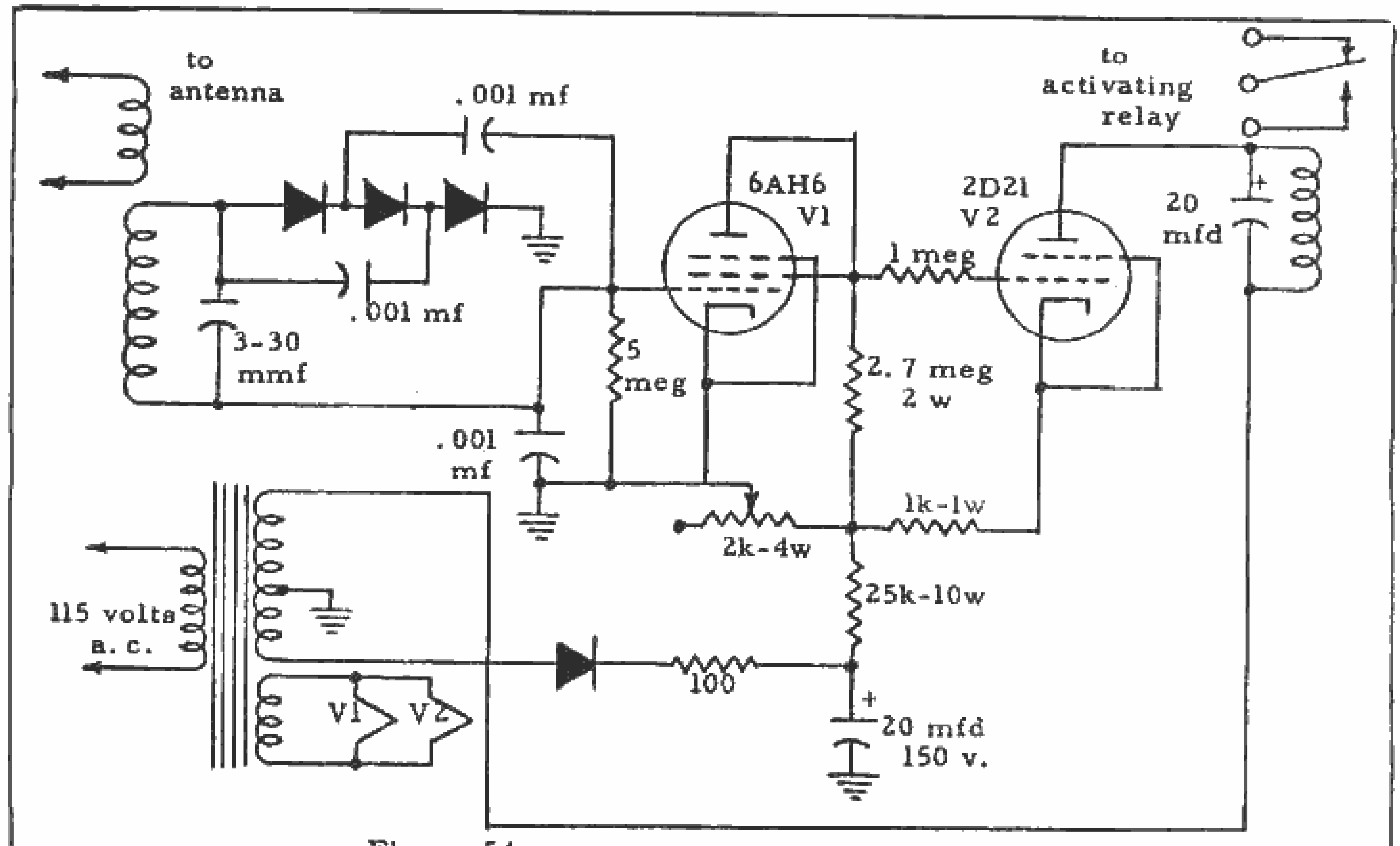

to
antenna
.001 mf
to
activating
relay
6AH6
V1
2D21
V2
20
mfd
1 meg
.001 mf
3-30
mmf
5
meg
2.7 meg
2 w
.001
mf
1k-1w
2k-4w
25k-10w
115 volts
a.c.
100
V1
V2
20 mfd
150 v.

Figure 54. Receiver

they were highly impractical. Electronics, conversely, is the essence of practicality.

The science of electronics is of recent origin; it is an area of the most intense specialization; in some applications, and to the uninitiated, it even smacks of the occult arts. Therefore, it is to be assumed that many juries and judges will be extremely reluctant to deprive a litigant of freedom or perhaps of life without the presentation of clear and irrefutable proof that electronics was at the root of the crime.

The investigator will have to be meticulous in his observations and in his preservation of physical evidence. Preliminary reports, though sketchy, have already pointed to the fact that if tests of confiscated electronic gear are necessary, they must be conducted at the scene and under exactly the same conditions in which they were originally intended to be used. If this procedure is not followed, their probable value as evidence will be nullified.

If this sounds like the beginning of an uphill struggle, the implied impression is correct. The dream of the arsonist is to commit a crime that will appear as though it occurred from natural circumstances. The investigator must first prove the existence of the corpus delicti. If electronics is involved, he must ferret out the details as to how it was used, and must then convince people, often hostile and uninformed, of these facts. Hostility may, with certainty, be expected, since humanity tends to distrust that which it does not understand.

On the other side of the coin, the officer must guard against an overzealous attitude in seeking to prove the use of electronics in a criminal situation. All electronics engineers, mathematicians and technicians who sustain a loss are not necessarily incipient criminals. They may deal in commodities that are, in the vernacular, "way-out," but they may not have used these abilities for the wrong purposes. Radio "hams" and experimenters, for example, might possess a welter of electronic equipment, but would have every right to possess it and to work with it in a normal way.

In this final analysis, it is the purpose of this article to show some of the things that can be done with electronics; to set forth the proposition that they probably *are* being done and *will continue to* be done; and to encourage the investigator to study enough of this art so that it might be able to furnish the key in explaining some enigmatic circumstance.

DEPARTMENT OF THE NAVY · UNITED STATES MARINE CORPS

U.S. MARINE CORPS HAND-TO-HAND COMBAT

US MARINE CORPS (NAVMC 1146-AO3)

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Section 1

INTRODUCTION

101. IMPORTANCE OF HAND-TO-HAND FIGHTING

a. Offensive–defensive hand-to-hand fighting is a composite of boxing, wrestling, karate, judo, and football. It is easily taught, easily learned, and extremely effective for offense or defense.

b. In many situations, when weapons are either not available or their use is impractical or impossible, particularly when silence is desirable, the employment of the techniques of hand-to-hand fighting is of inestimable value. It provides the individual with a most effective means of executing a decisive attack or assault on an opponent, or of adequately defending himself. Mastery of the art of hand-to-hand fighting adds immeasurable assurance, confidence, and self-reliance to the individual Marine.

102. PURPOSE AND SCOPE

The purpose of this manual is to teach some of the techniques of hand-to-hand fighting. Movements are described and illustrated in sequence to serve as a guide for teaching and learning.

2

103. INSTRUCTIONAL PROCEDURES

During the first period of instruction, the instructor explains and demonstrates how hand-to-hand fighting is designed to place the user in position to utilize his full strength and leverage against his opponent's vulnerable, vital, or more sensitive areas, i. e., the arch of the foot, the knee, the groin, the temple, the ears, the nerves under the ears, the solar plexus, the throat, the bridge of the nose, the elbow, the collarbone, the eyes, the neck, the side of the jaw, the base of the spine, the small of the back, and the kidneys. The fingers, wrist, and elbow are the easiest bones to break or dislocate. In this regard, students learning the movements of hand-to-hand fighting must be cautioned to exert care so as not to accidentally injure or immobilize those with whom they are training.

104. PRINCIPLES OF HAND-TO-HAND FIGHTING

Basic principles which the hand-to-hand fighter must constantly bear in mind are:

a. Be aggressive.
b. Keep eyes on the opponent.
c. Distract the opponent.
d. Disable or be disabled.
e. Vary the attack to fit the situation.
f. Turn the defense into an unrelenting attack.
g. Feel superior to the opponent, regardless of the latter's size or evidence of strength.

3

Section 2

STANCE AND MOVEMENT

201. OFFENSIVE–DEFENSIVE STANCE

a. To assume the OFFENSIVE–DEFENSIVE STANCE, the hand-to-hand fighter:

(1) Faces his opponent with the left foot forward; points toe of left foot slightly inward.
(2) Bends left knee slightly inward.
(3) Places the right foot to the rear and right of the left foot.
(4) Points right toe straight to the front with the right knee slightly bent.
(5) Leans forward from the hips with the weight balanced on both feet.
(6) Raises the left hand so that it protects the left side of the face and head.
(7) Positions the left forearm and elbow to protect the left side of the body.
(8) Raises the right hand to protect the right side of the face and head.
(9) Positions the right forearm and elbow to protect the right side of the body and head.
(10) Points the palms of the hands inward with the lower edge of the hands facing the opponent.
(11) Holds the fingers together with the thumbs held tight against the forefingers.

4

b. From this position the hand-to-hand fighter is prepared to strike or grasp his opponent.

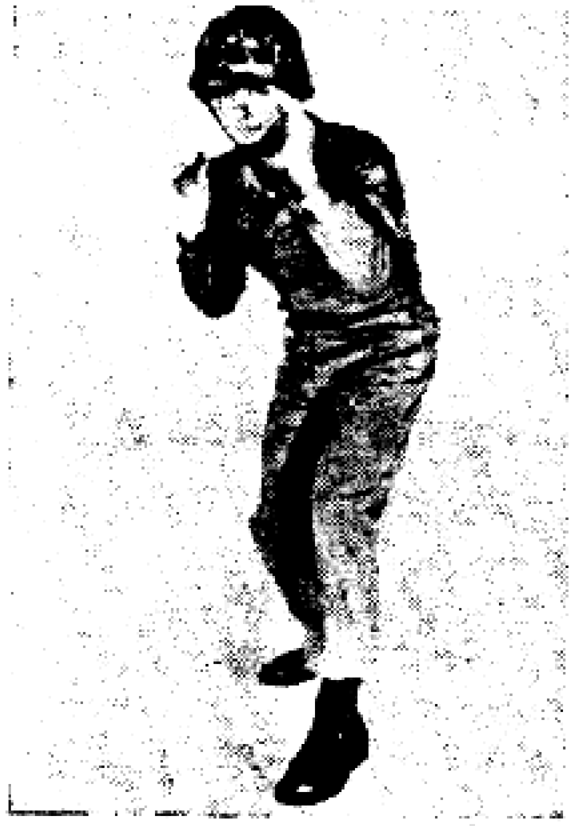
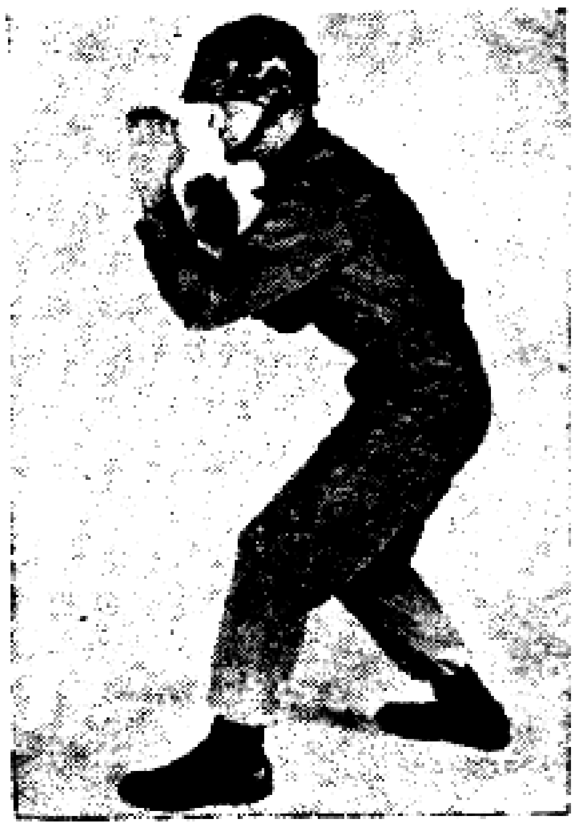


Figure 1.—The offensive–defensive stance.



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202. OFFENSIVE-DEFENSIVE MOVEMENT

In the execution of the various movements from the OFFENSIVE-DEFENSIVE STANCE, the hand-to-hand fighter will move as follows:

a. To move forward: lift the left foot and move it forward about 14 inches; the right foot follows.

b. To shift left and forward: step left and forward with the left foot, pivoting on the ball of the right foot.

c. To shift right and forward: step to right and forward with the right foot, pivoting on the ball of the left foot.

d. To shift left and to the rear: step back and to the left with right foot, pivoting on the ball of the left foot.

e. To shift right and to the rear: step left and to the rear with the left foot, pivoting on the ball of the right foot.

f. To move directly to the rear: move the right foot approximately 14 inches to the rear; the left foot follows.

7

Section 3

FALLS AND ROLLS

301. FORWARD ROLL

To take a FORWARD ROLL, the hand-to-hand fighter:

a. Takes two steps forward to build up momentum.

b. Dives toward the ground.

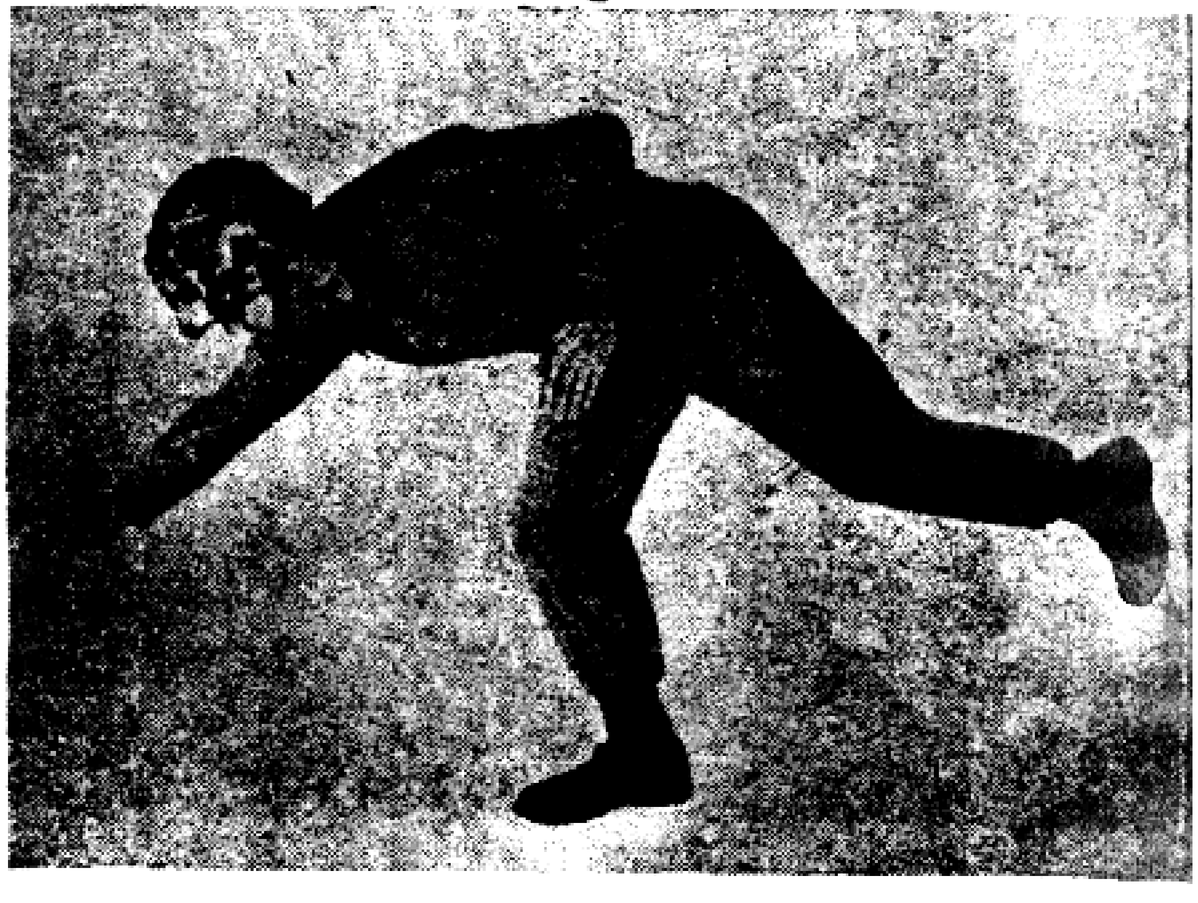

Figure 2.—The forward roll.

8

c. Places the chin against the left shoulder.

d. Places the left hand at the left side of, and slightly above the head.

e. Bends the right arm slightly at the elbow, breaking the fall with right hand and forearm.

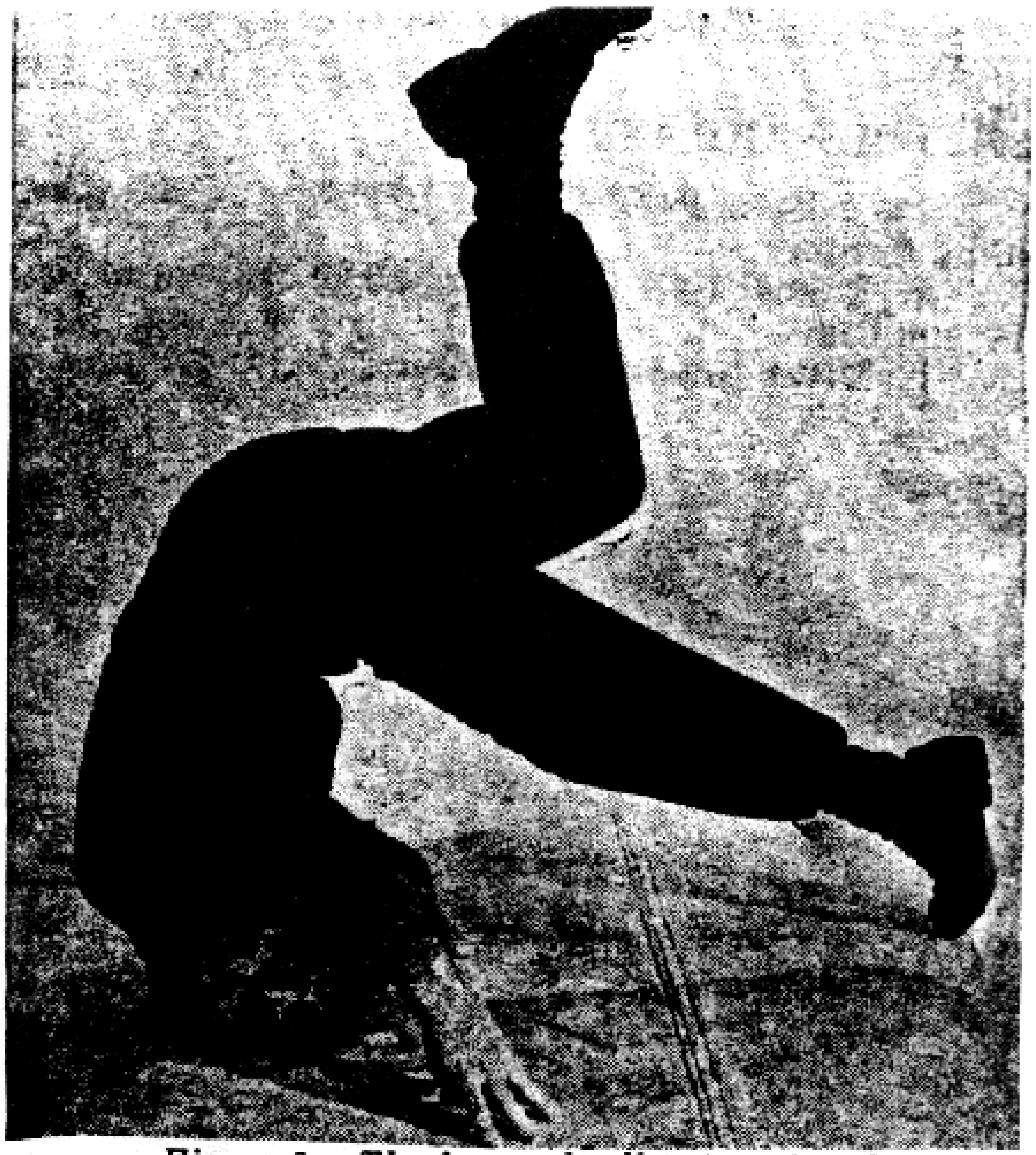

Figure 2.—The forward roll.—(continued)

9

f. Rolls forward on the right shoulder and the back when the left hand makes contact with the ground.

g. Spins to the left when the feet make contact with the ground, facing the rear, in the offensive-defensive stance.

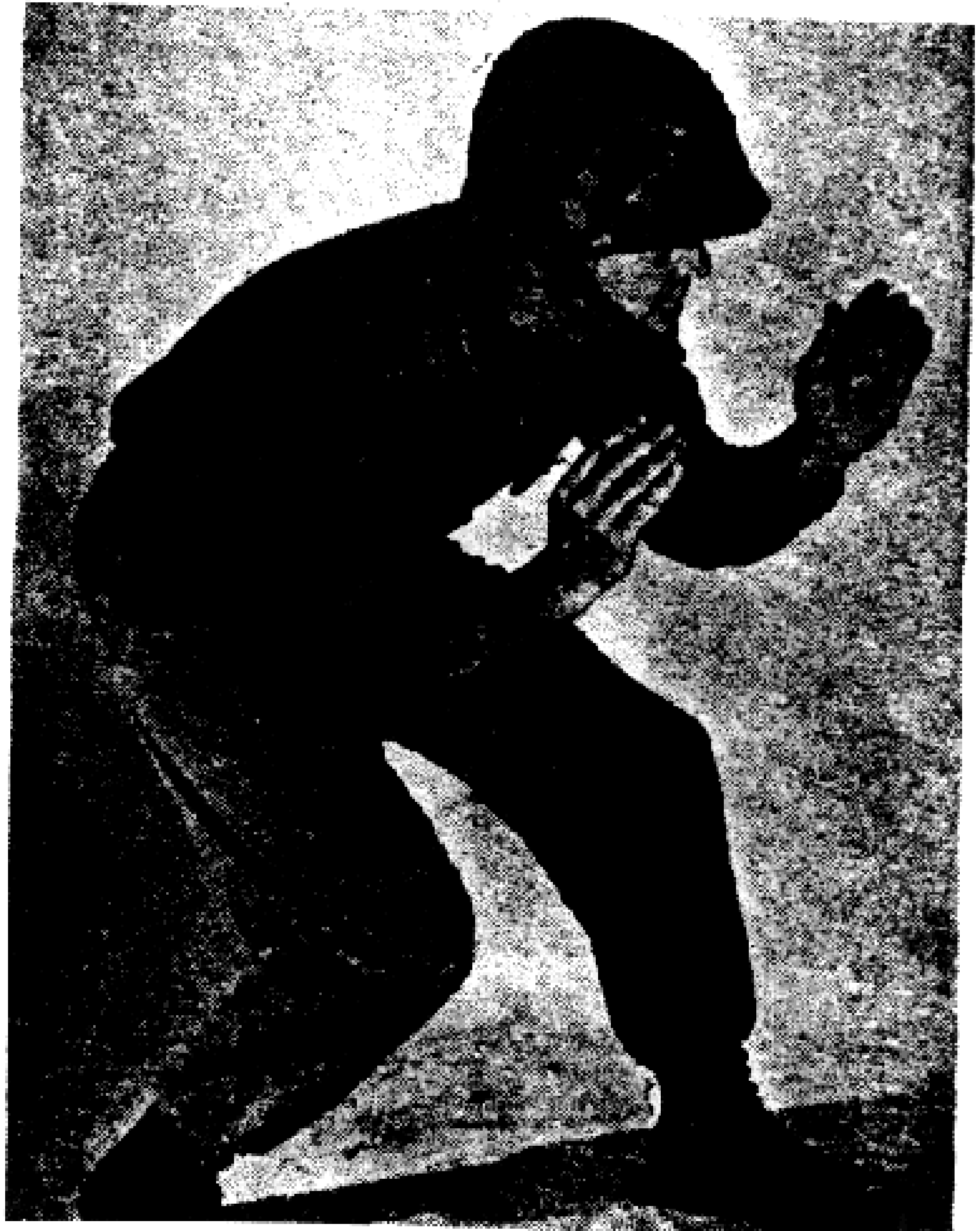

Figure 2.—The forward roll.—(continued)

10

302. BACKWARD FALL

To take a BACKWARD FALL, the hand-to-hand fighter:

a. Drops directly back on the buttocks as in sitting position, breaking the shock of the fall with the hands and forearms.

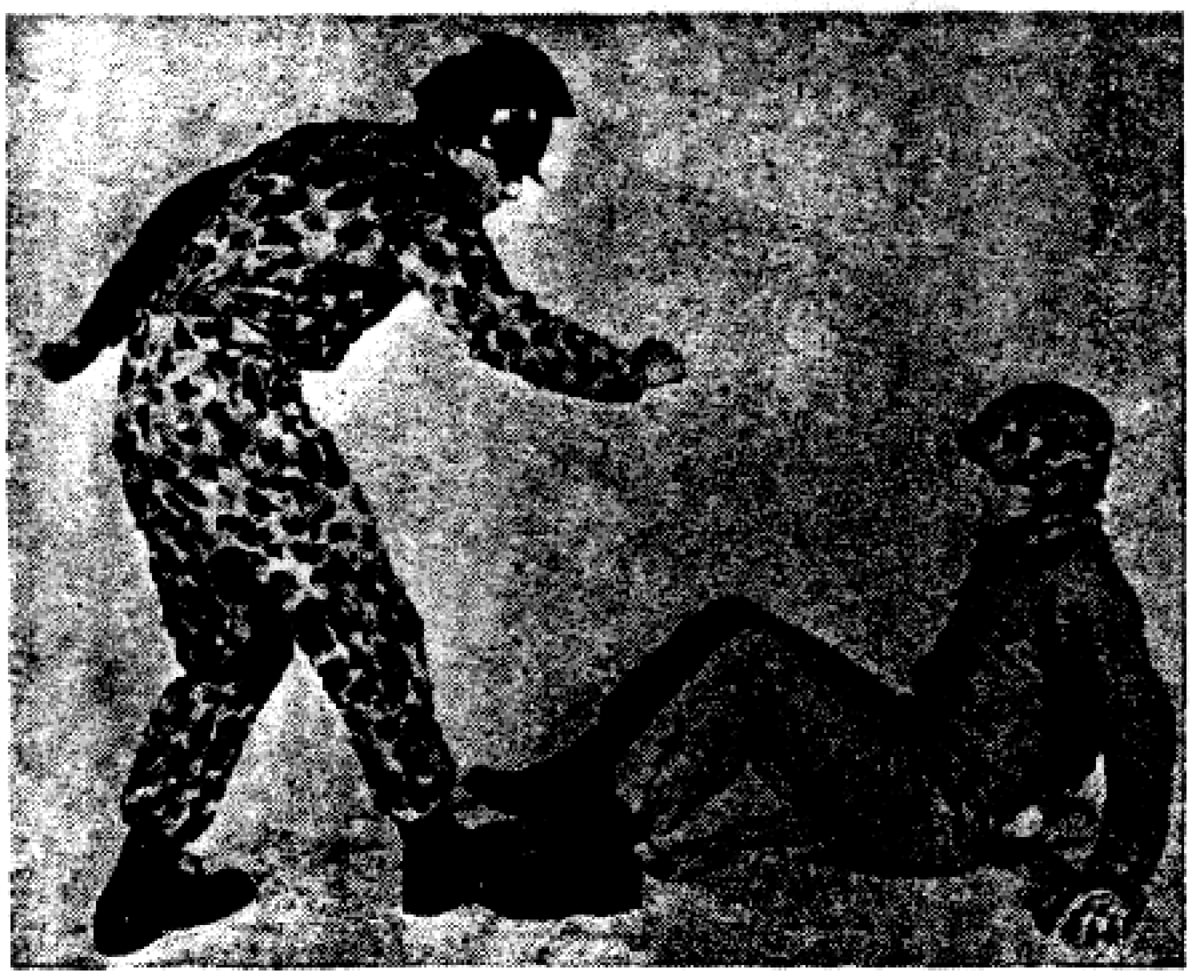

Figure 3.—The backward fall.

b. Places the head on the chest.

c. Raises the feet and swings them over the head, in a backward somersault movement, when the hands touch the ground.

11

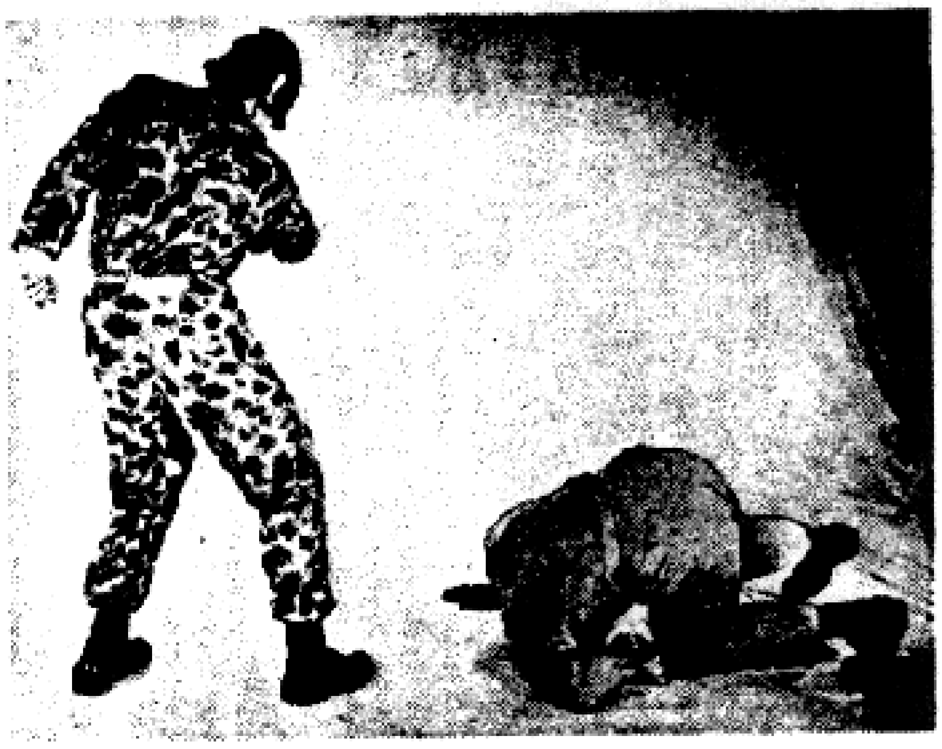

Figure 3.—The backward fall.—(continued)

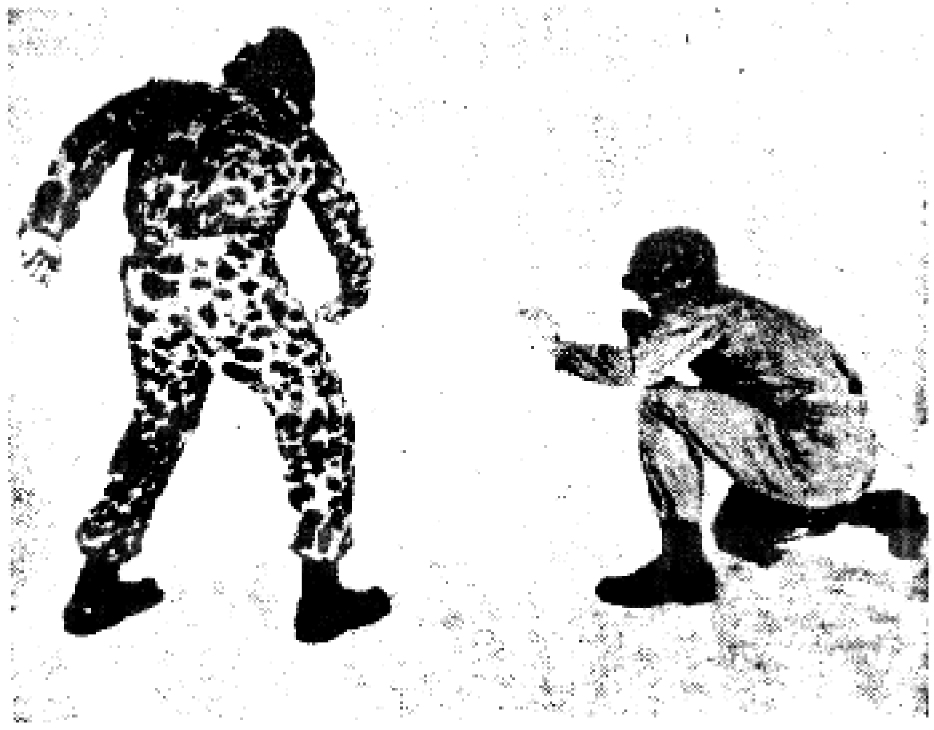

Figure 3.—The backward fall.—(continued)

d. Lands on the knees, or feet, facing his opponent, and assumes the OFFENSIVE–DEFENSIVE STANCE immediately.

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Section 4

DEFLECTING AND STRIKING BLOWS

401. DEFLECTING A RIGHT HAND BLOW

When an opponent attempts to strike with a straight right hand blow, the hand-to-hand fighter will deflect the blow to the right with his left hand. He will then shift left and forward, pulling his opponent forward with his left hand on his opponent's wrist. He then strikes his opponent on the temple, throat, or side of the neck with the back edge of his hand.

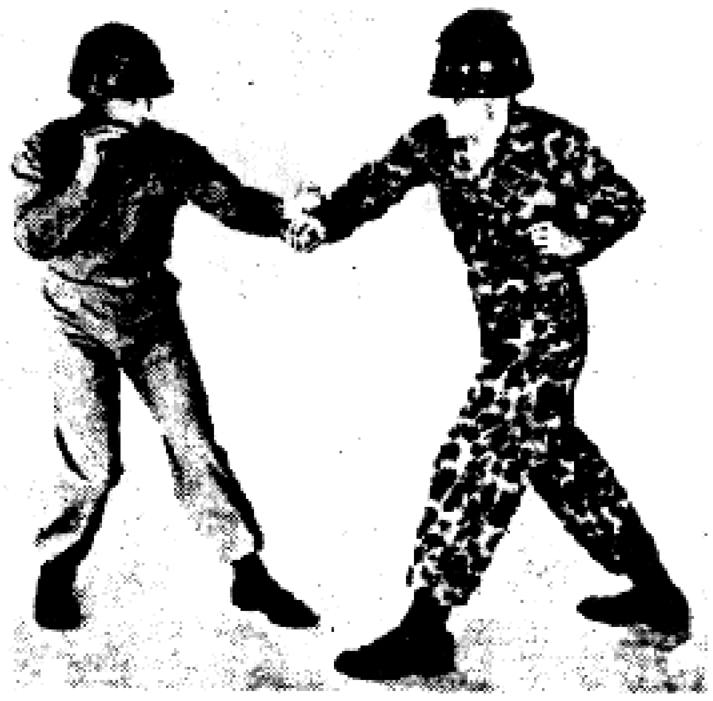

Figure 4.—Deflecting a right hand blow.

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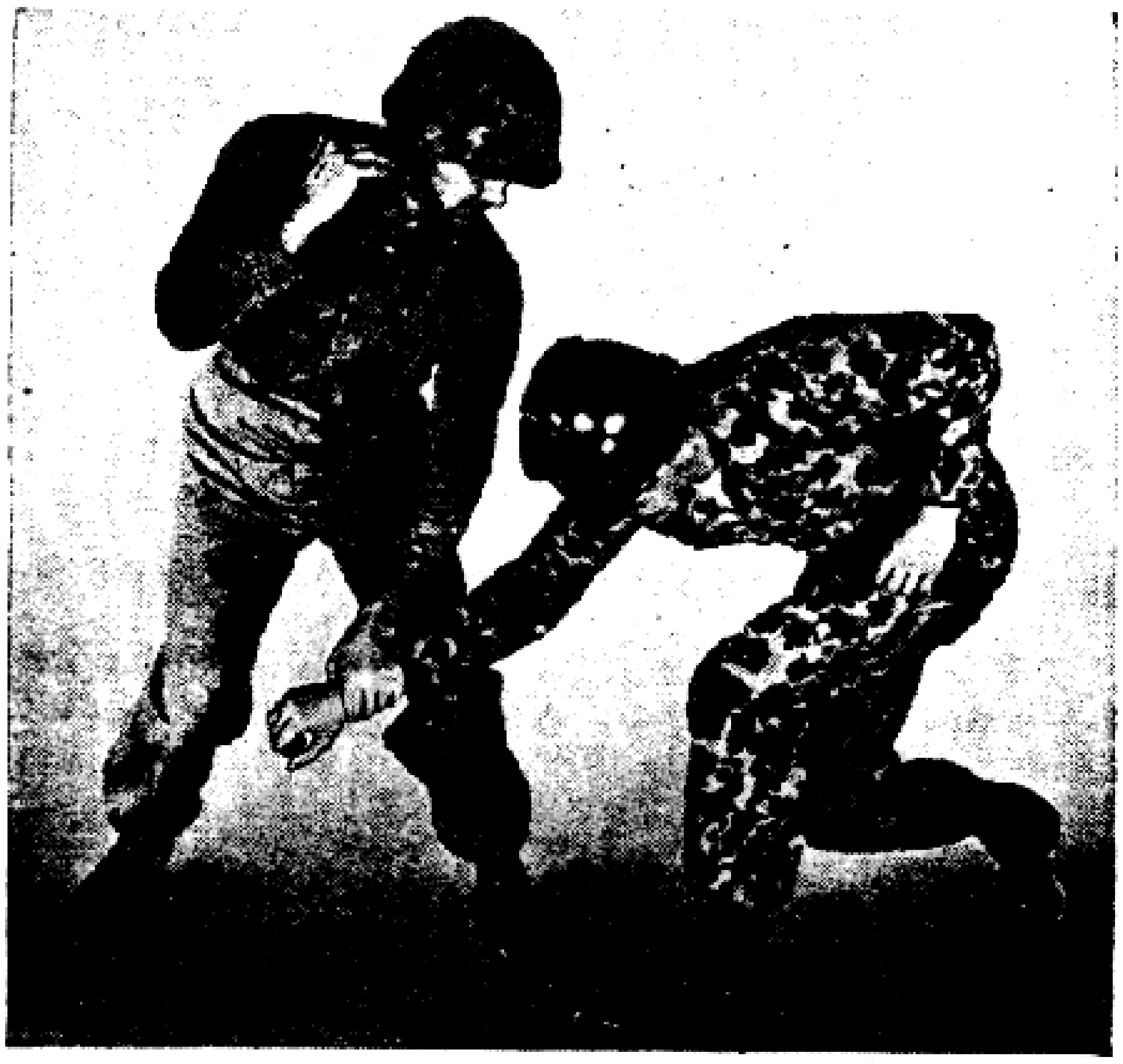


Figure 4.—Deflecting a right hand blow.—(continued)

402. DEFLECTING A LEFT HAND BLOW

When an opponent attempts to strike with his left hand, the hand-to-hand fighter will deflect the blow to the left with his right hand, or forearm, and grasp the opponent's left arm with his own left hand. He then shifts forward and right, striking at his opponent's temple, jaw, or base of skull with the back edge of his right hand, utilizing momentum gained in the shift to add force to the blow.

15

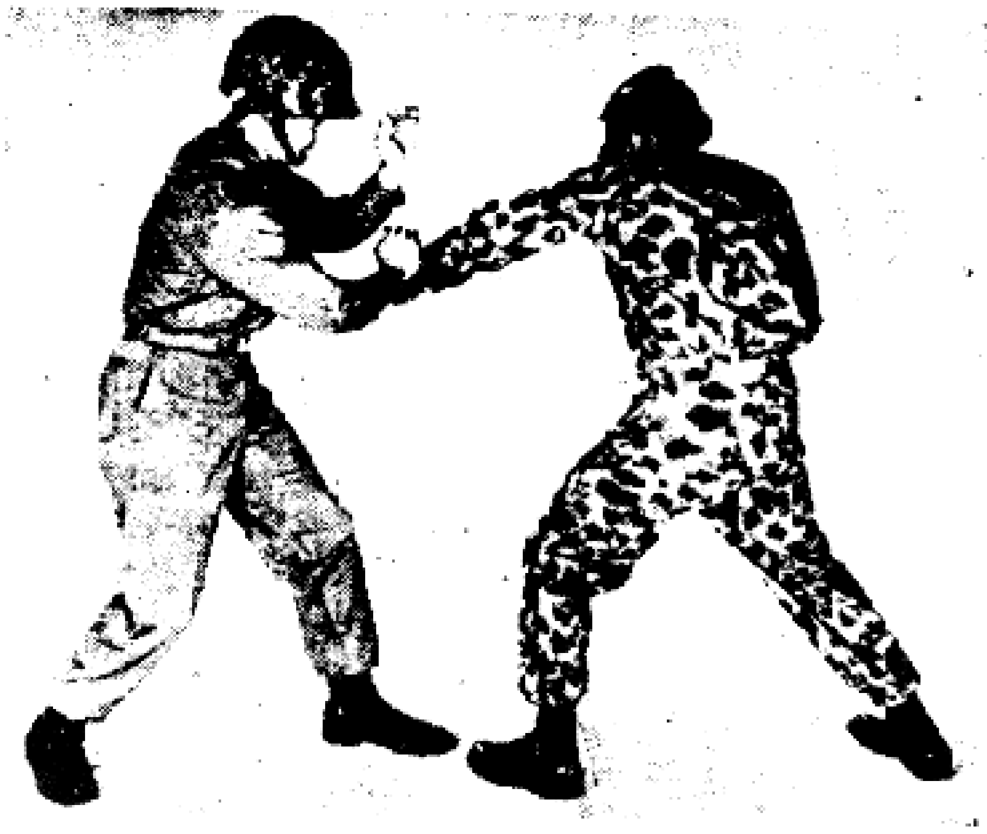
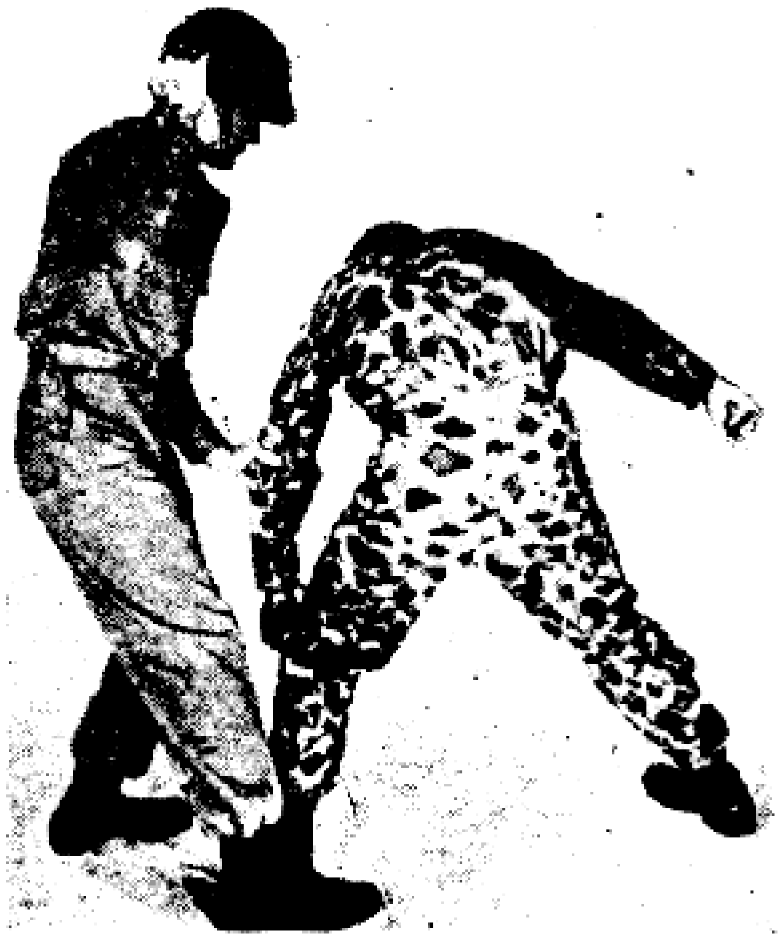


Figure 5.—Deflecting a left hand blow.



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403. BLOCKING A WIDE SWINGING RIGHT HAND BLOW

When an opponent attempts to strike with a wide swinging right hand, or roundhouse right blow, the hand-to-hand fighter blocks the blow with his left hand, or forearm. He grasps the opponent's right wrist or arm with his left hand and pulls him forward, striking the opponent simultaneously in the groin with the right knee, and between the eyes with the back edge of the right hand. He pivots left, throwing the opponent over the right thigh or knee.

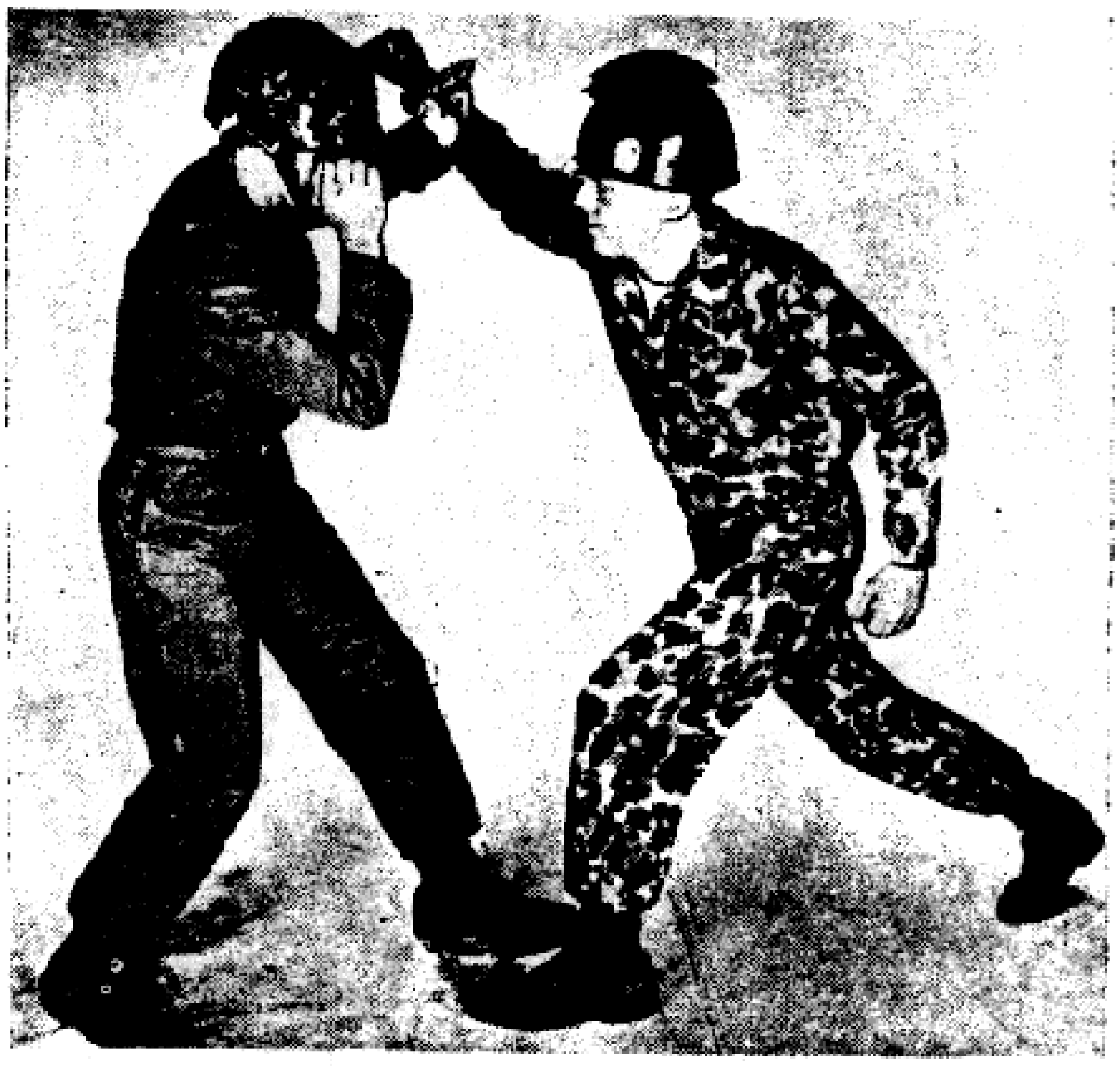

Figure 6.—Blocking a wide swinging right hand blow.

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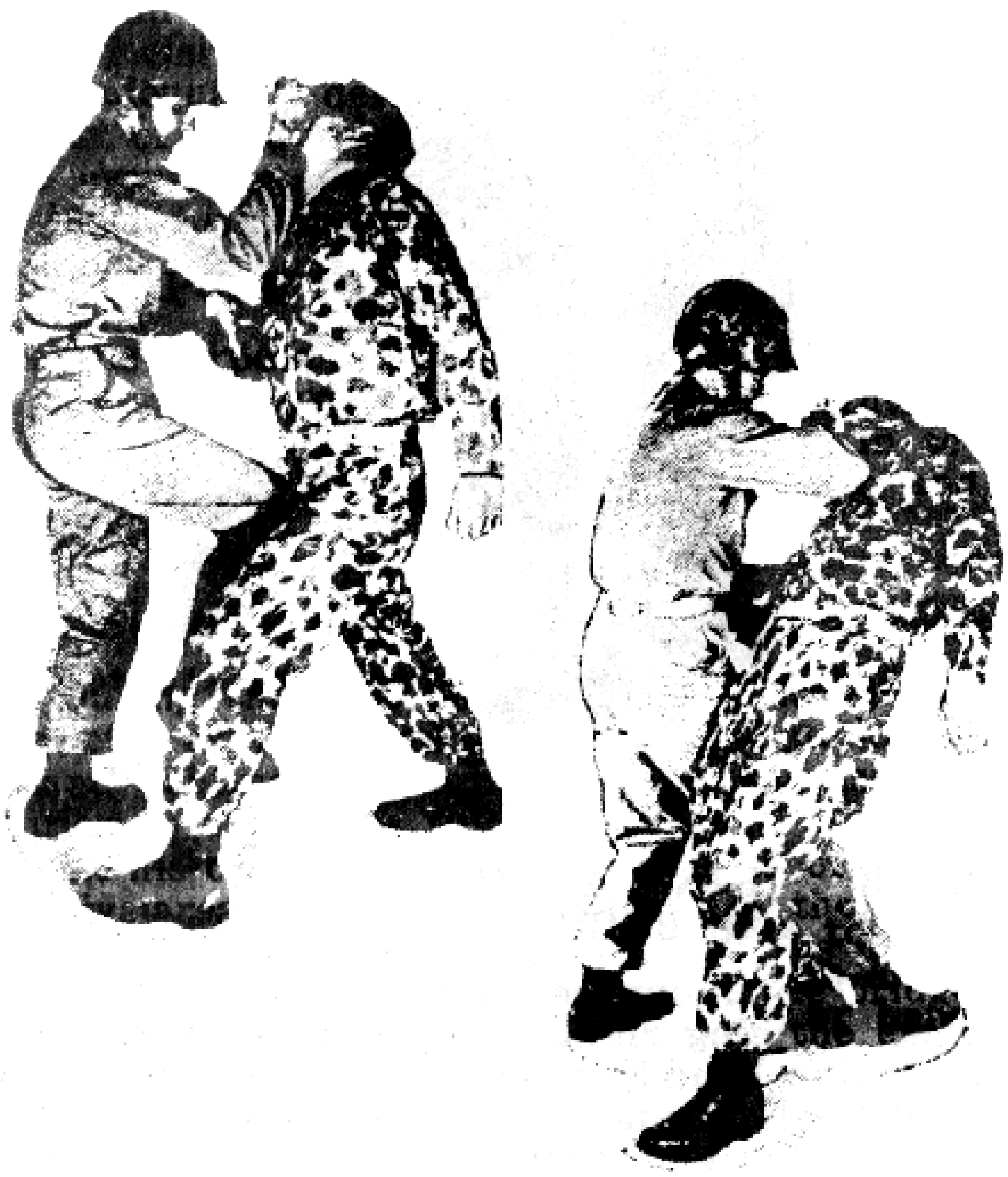

Figure 6.—Blocking a wide swinging right hand blow.—(continued)

18

404. ATTACKING AN OPPONENT

If an opponent threatens to strike with a left hand blow, the hand-to-hand fighter strikes the outside of his opponent's left wrist with his left hand. He shifts right and forward and delivers a blow to the temple, jaw or base of the skull with his right hand.

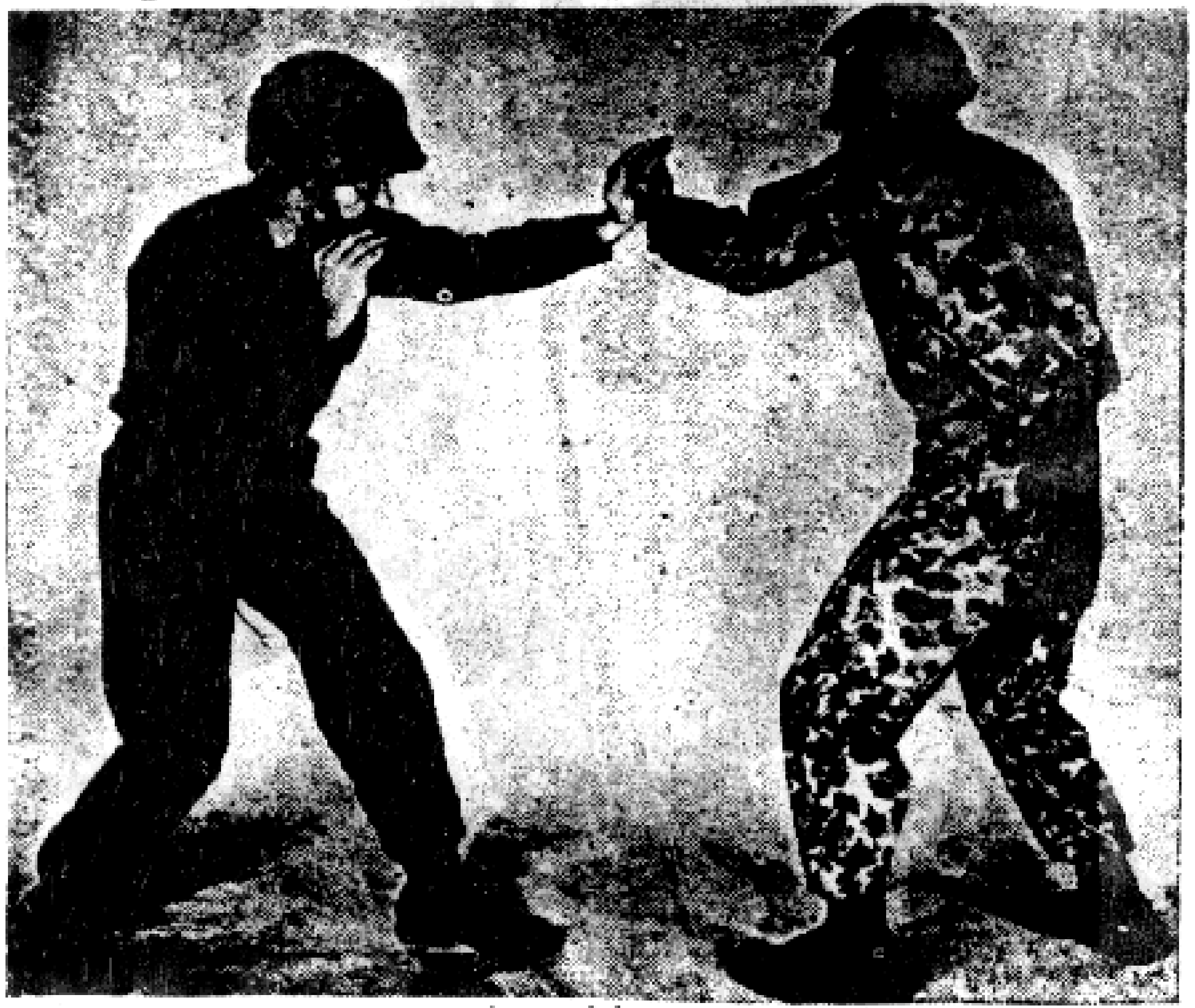

Figure 7.—Attacking an opponent.

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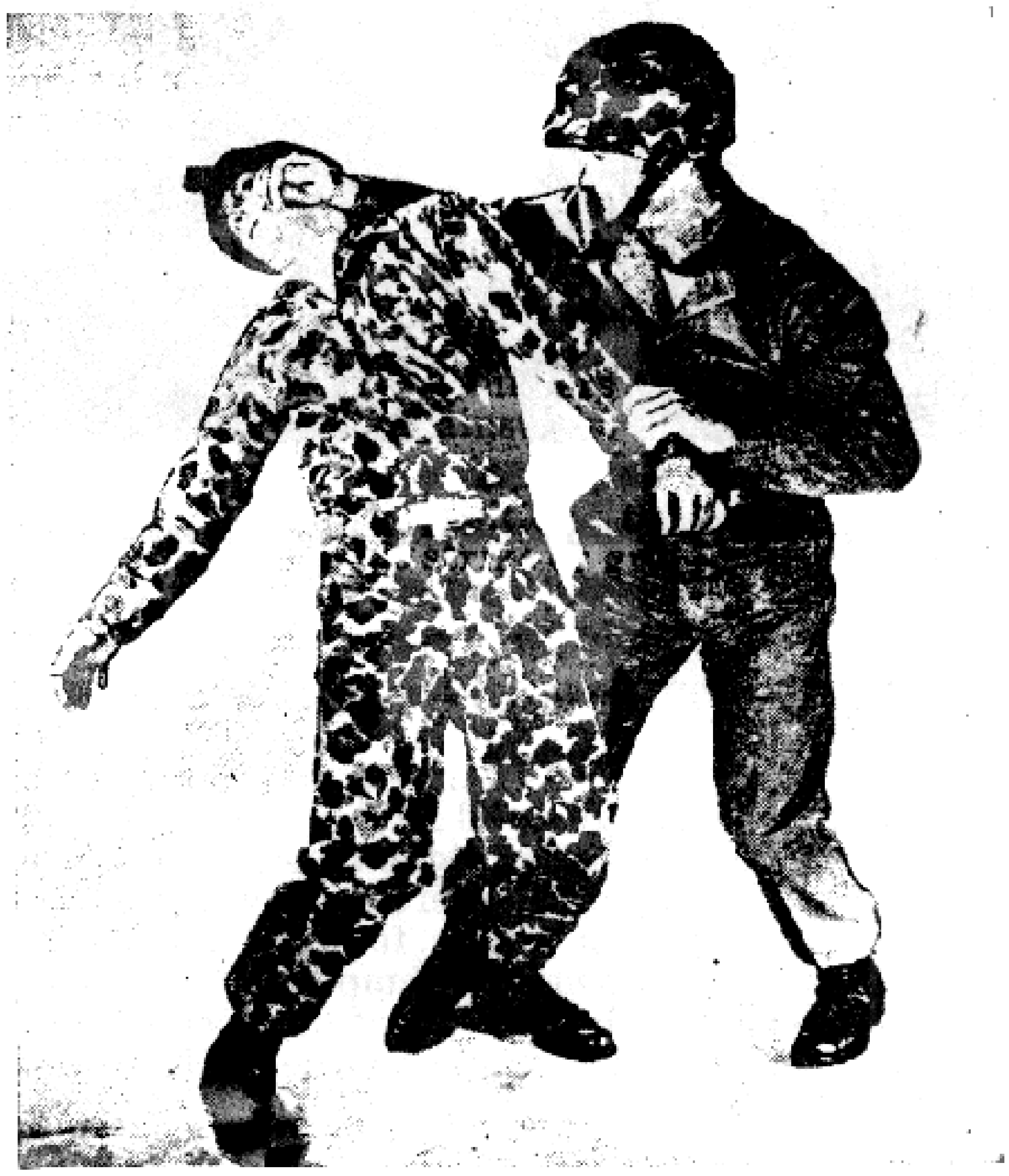


Figure 7.—Attacking an opponent.—(continued)

20

405. DEFLECTING KICKS

If an opponent attempts to kick with his right foot, the hand-to-hand fighter shifts forward and left, deflecting the kick to the right and upward with his left hand. He swings or raises his opponent's right leg upward, knocking him over on his back, where the opponent's leg can be broken, or where the hand-to-hand fighter can deliver a kick to his opponent's groin, or a karate blow to the throat or bridge of the nose. If the opponent attempts a kick with his left foot, the hand-to-hand fighter will shift right and carry out the same disabling procedure.

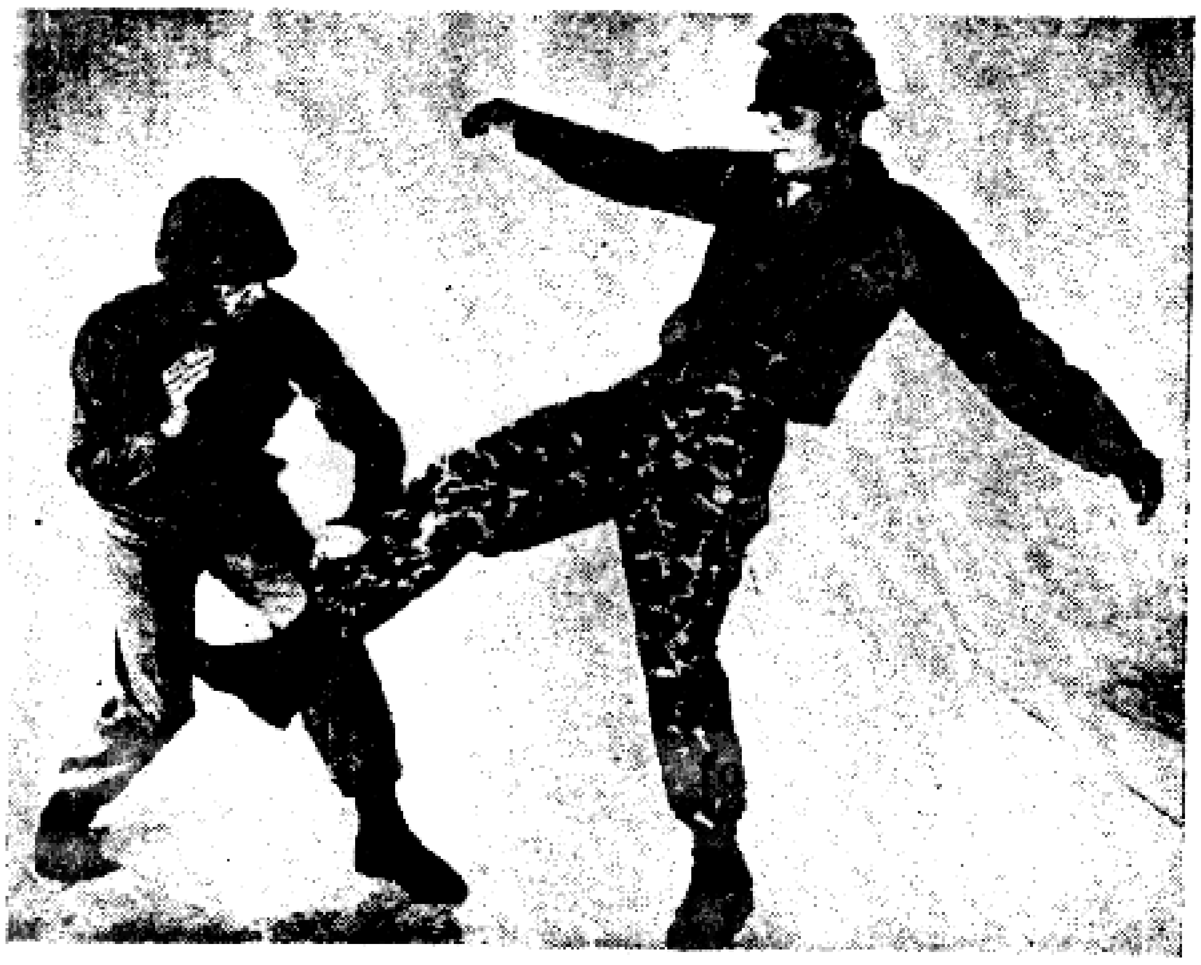


Figure 8.—Deflecting kicks.

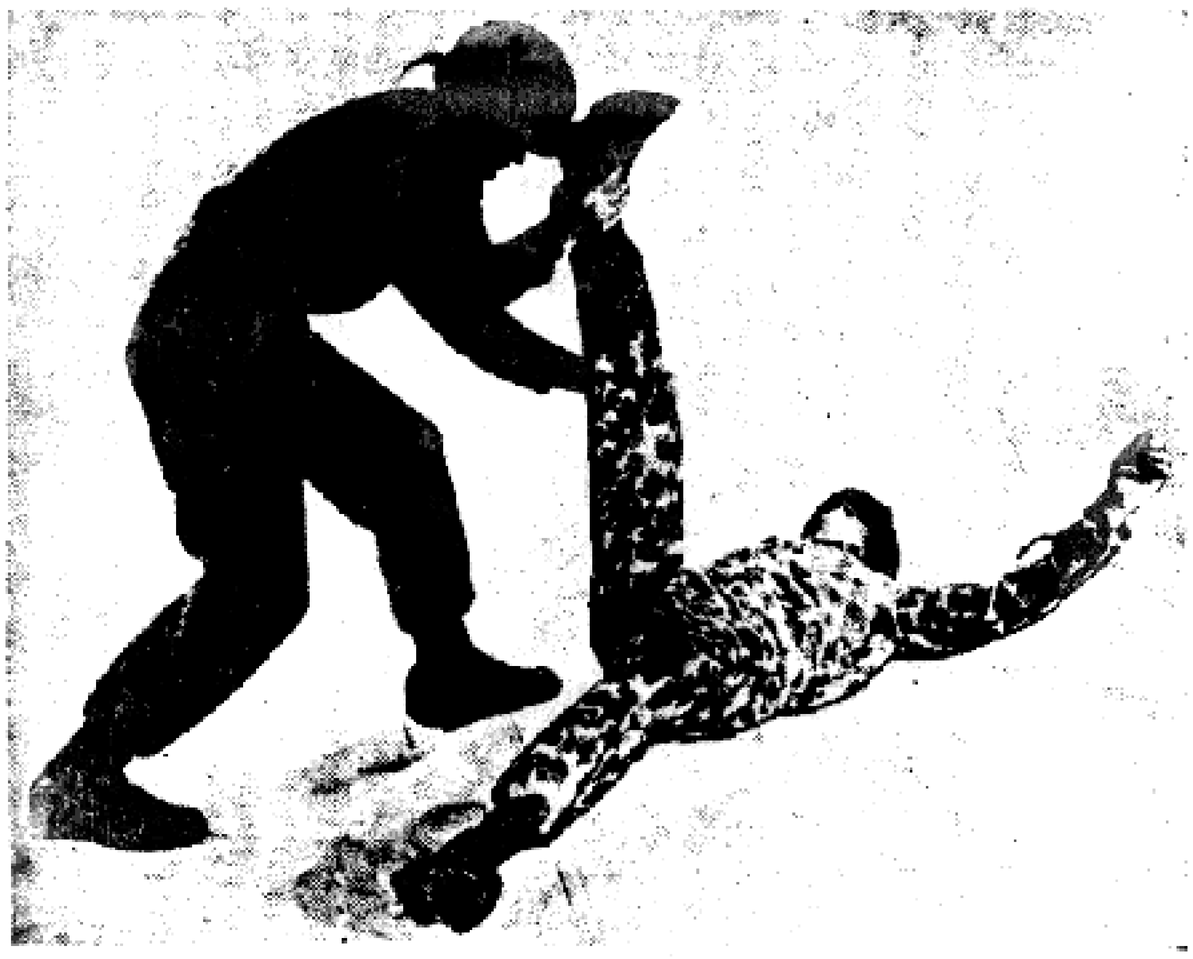


Figure 8.—Deflecting kicks.—(continued)

Section 5

THROWS AND TAKE-DOWNS

501. TAKE-DOWN FROM AN OPPONENT'S LEFT

To take-down from an opponent's left, the hand-to-hand fighter grasps his opponent's left wrist with his left hand and steps toward the opponent with the right foot. He drives his knee

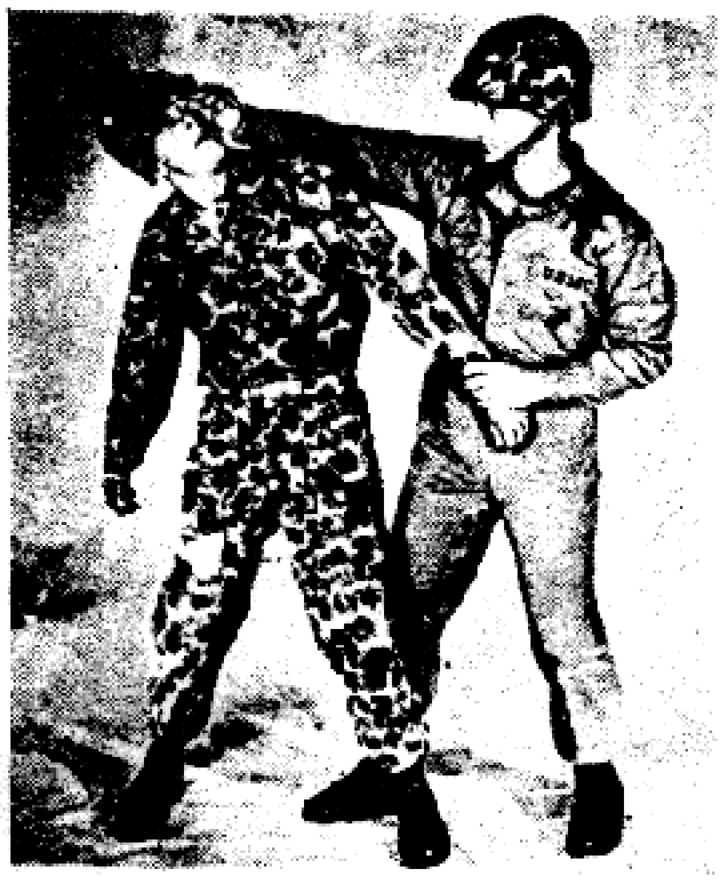


Figure 9.—Take-down from an opponent's left.

into the outside of his opponent's left knee, simultaneously striking his opponent on the temple with the outer edge of his right hand. He then places his right hand on his opponent's face, pushing him backward over his own right knee or thigh and dropping him. The hand-to-hand fighter can then follow through with a blow to the bridge of the nose or throat.

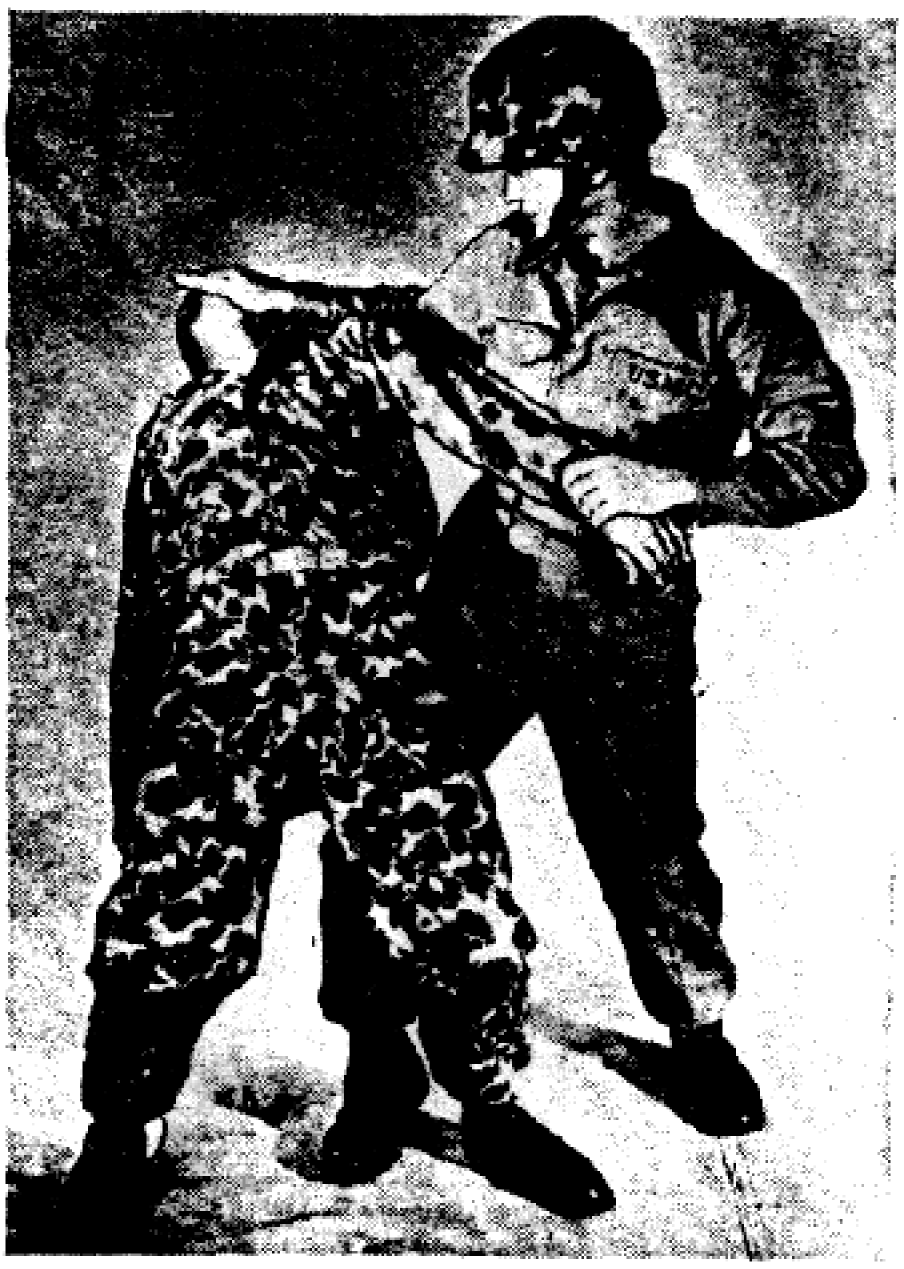


Figure 9.—Take-down from an opponent's left.—(continued)

502. TAKE–DOWN FROM AN OPPONENT'S LEFT (ALTERNATE METHOD)

To execute an alternate method of take–down from an opponent's left, the hand-to-hand fighter grasps his opponent's left wrist with his own left hand. He then steps forward with his right foot, driving his right knee into the outside of his opponent's left knee. He then pivots under his opponent's left arm, grasping the inside of his left leg at the knee, and drives his elbow into his opponent's solar plexus or groin. The hand-to-hand fighter then lifts upward with his right hand, and releases his opponent's left wrist when the latter begins to fall backwards. He follows through with a knee to his opponent's left side, and a right hand blow to his throat, or the bridge of his nose.

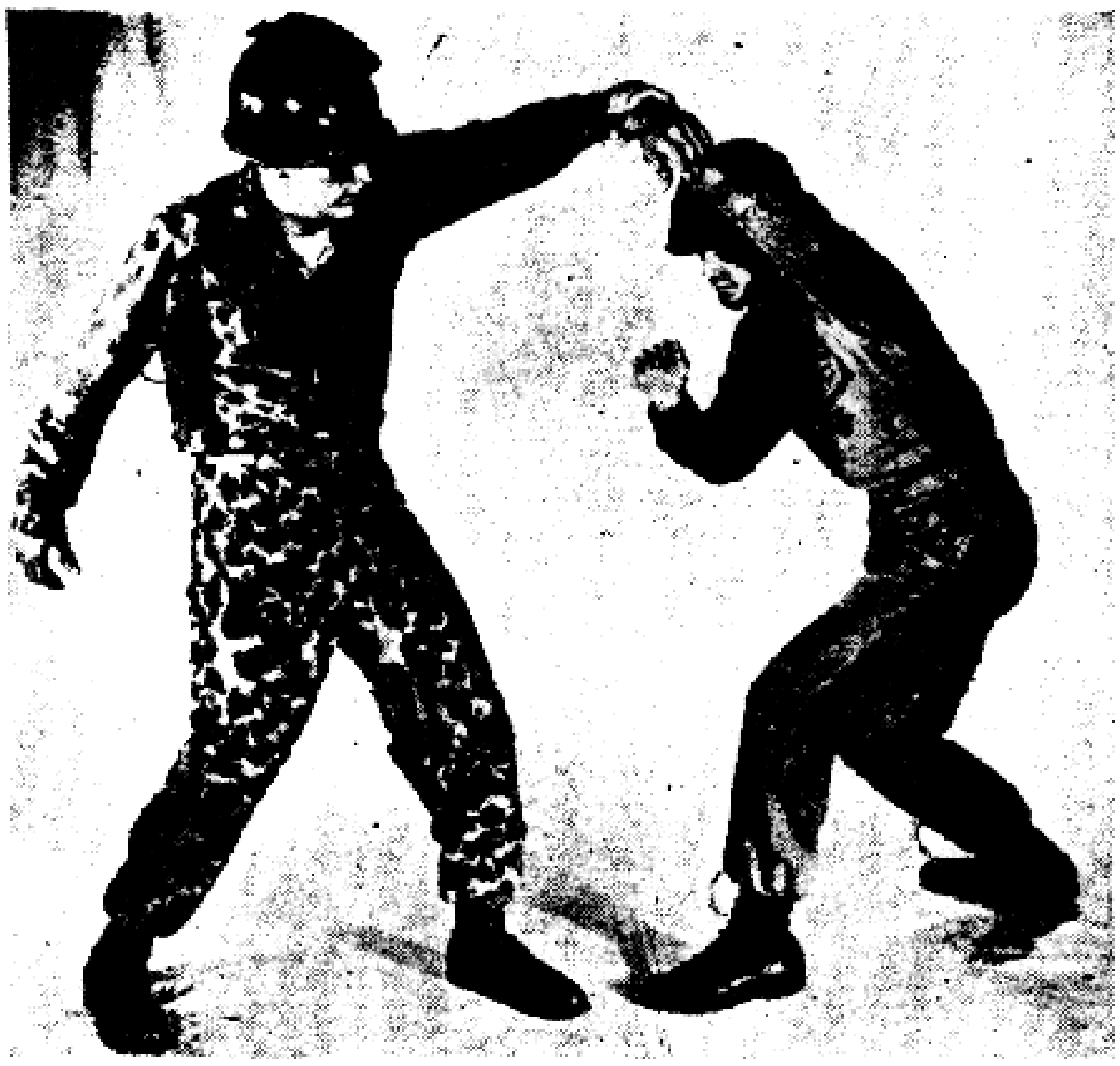


Figure 10.—Take–down from an opponent's left (alternate).

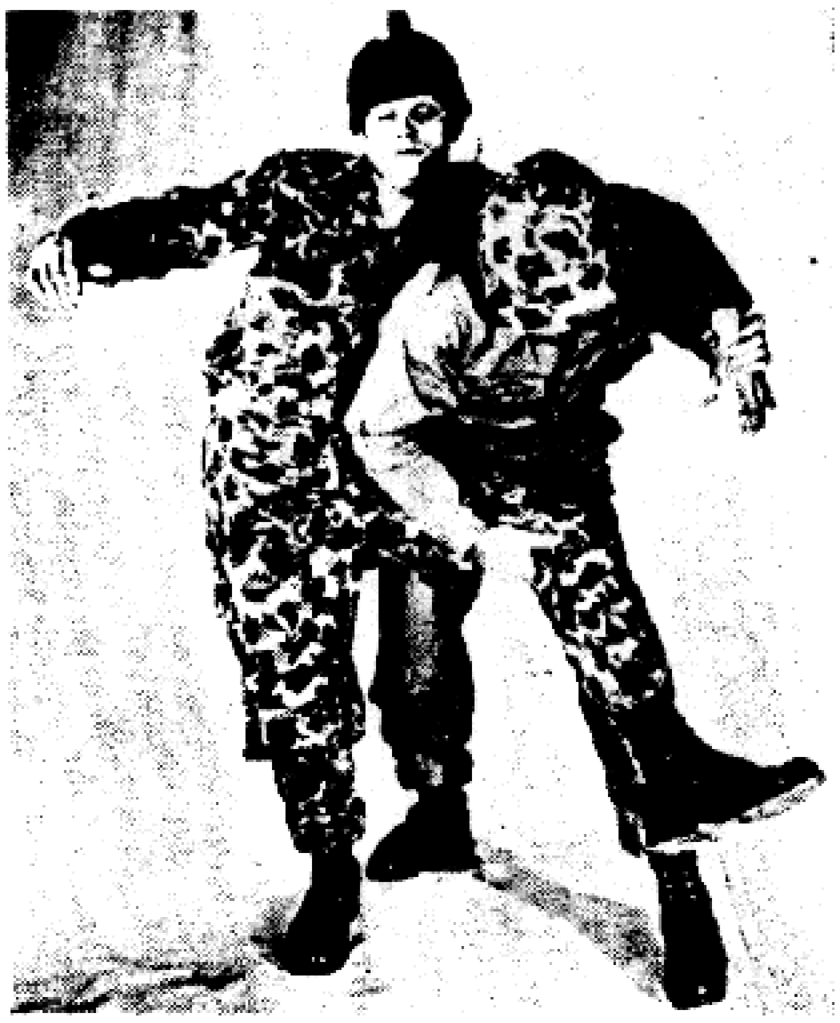
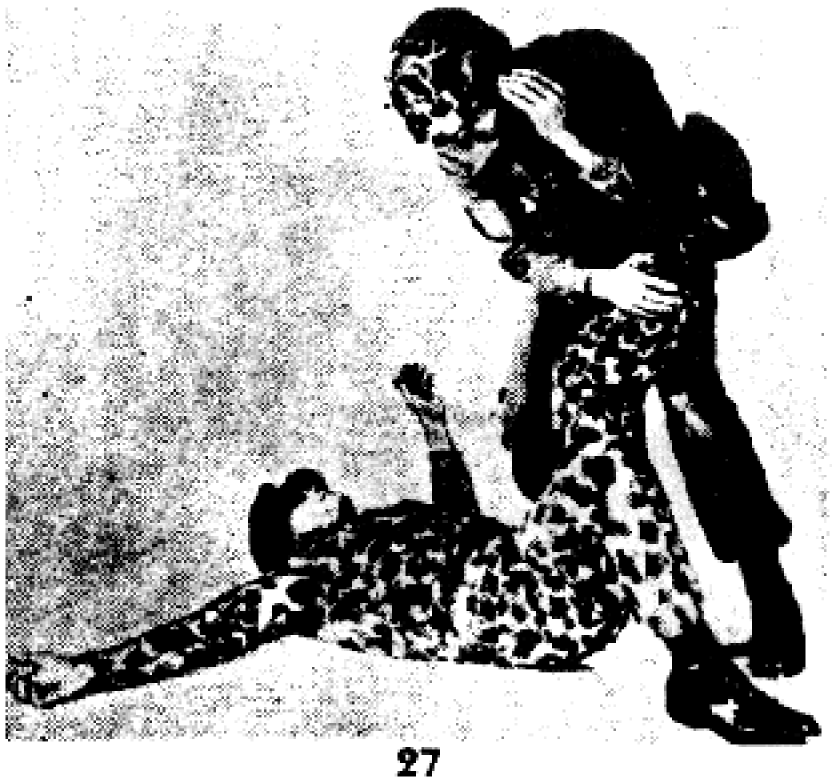


Figure 10.—Take–down from an opponent's left (alternate).—(continued)



503. TAKE–DOWN FROM AN OPPONENT'S RIGHT

To take–down from an opponent's right, the hand-to-hand fighter grasps his opponent's right wrist with his left hand, raising it above his head as he bends forward toward his opponent. He then drives his shoulder against his opponent's solar plexus, simultaneously stepping forward with his right foot to add momentum to the shoulder blow. As the opponent leans forward from the blow, the hand-to-hand fighter grasps the opponent's right leg at the knee, raising him up and swinging him over his own shoulder, still retaining the wrist grip. Once the opponent is down, the hand-to-hand fighter can deliver a blow to the temple, throat, or bridge of the nose.

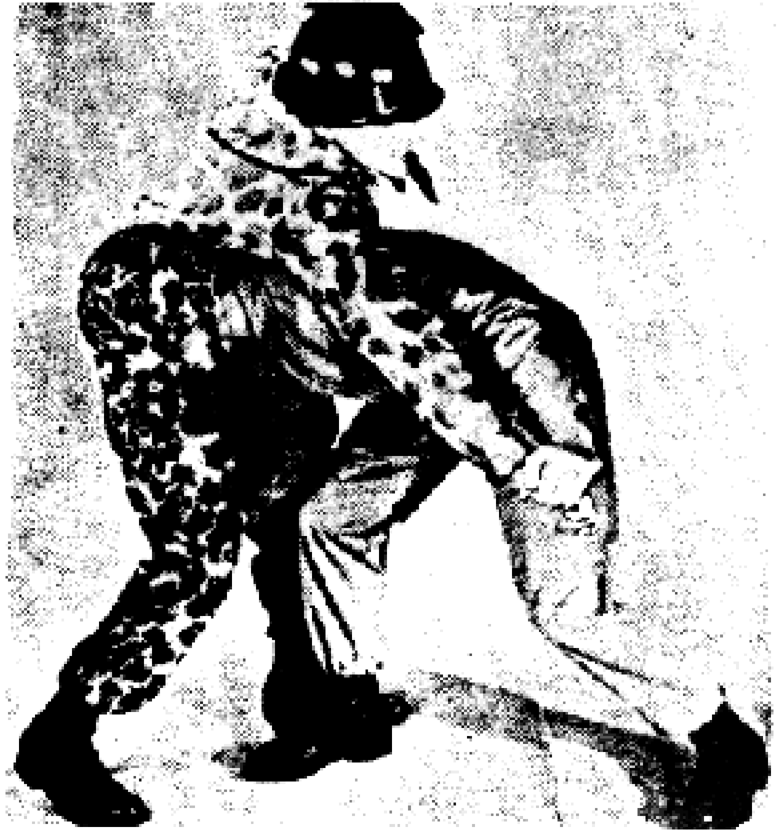


Figure 11.—Take–down from an opponent's right.

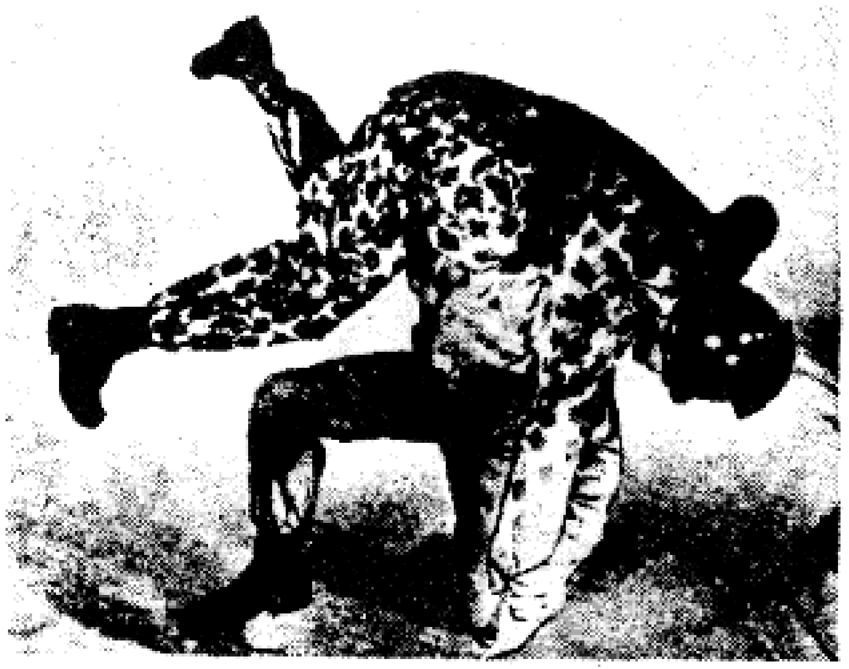
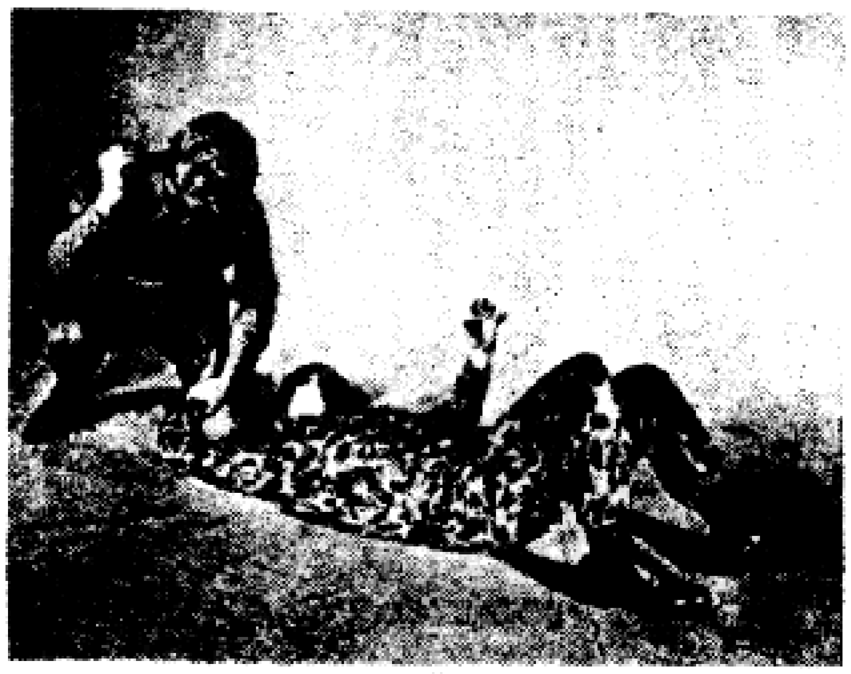


Figure 11.—Take-down from an opponent's right.—(continued)



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Section 6

BREAKING HOLDS

601. WRIST HOLD

To break a front wrist hold when the opponent is using both hands, the hand-to-hand fighter will pull back with his right hand and step forward with his left foot, simultaneously pushing forward and upward with his left hand. He then grasps his opponent's left elbow with his own left hand, and shifts right and forward. He follows through with a blow to the opponent's temple, jaw, neck, or kidney.

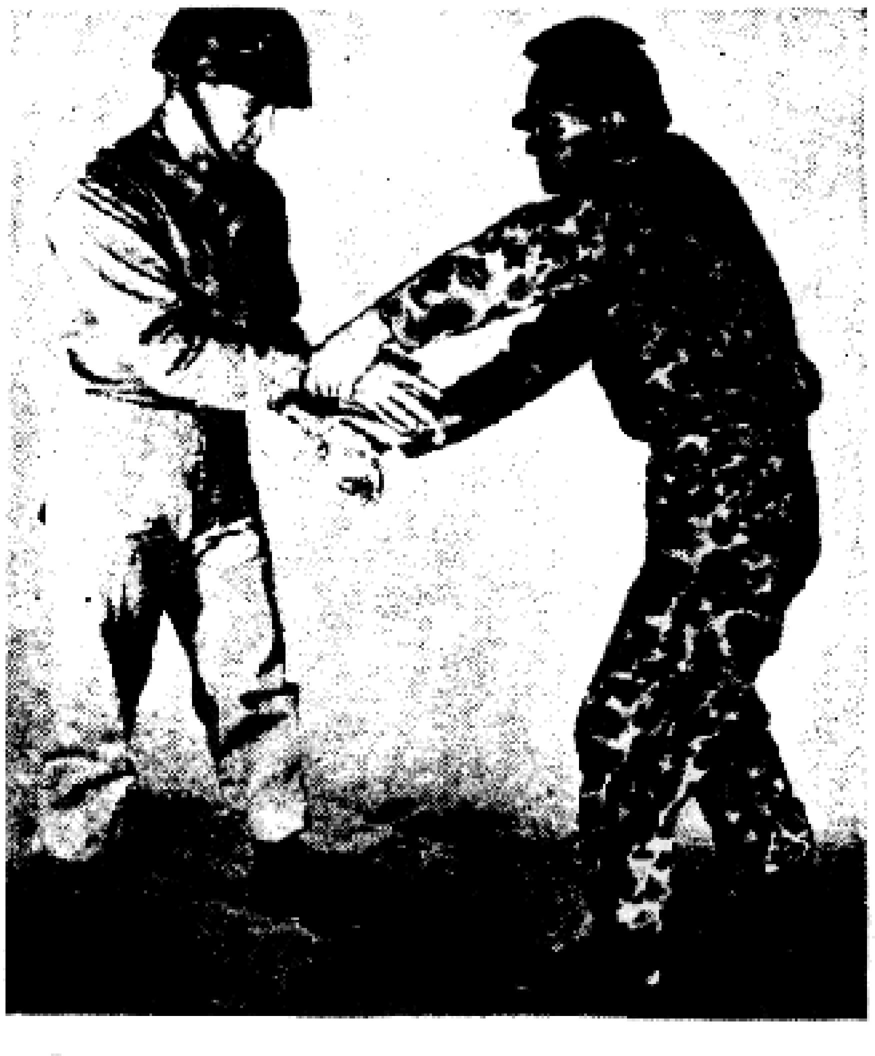

Figure 12.—Breaking front wrist hold.

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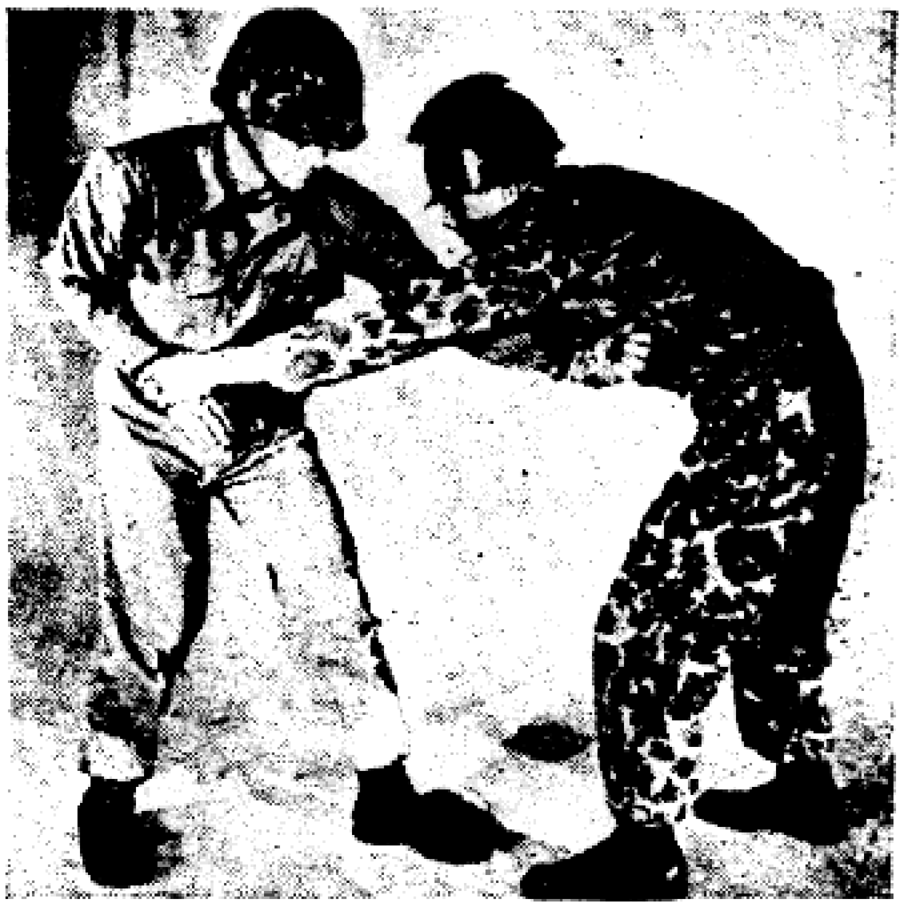
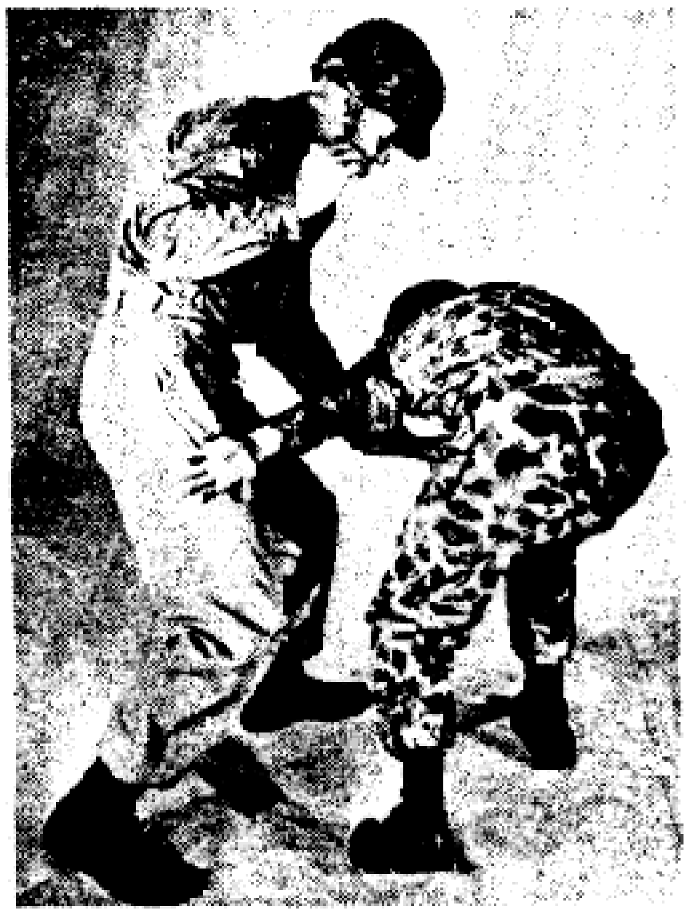


Figure 12.—Breaking front wrist hold.—(continued)



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602. REAR NECK HOLD

To break a strangle hold from the rear, when the opponent has locked his right hand on his left arm and is pushing forward on the hand-to-hand fighter's head with his left hand, the hand-to-hand fighter grasps the opponent's right elbow with his right hand, and the latter's left elbow with his left hand. He then pulls downward with

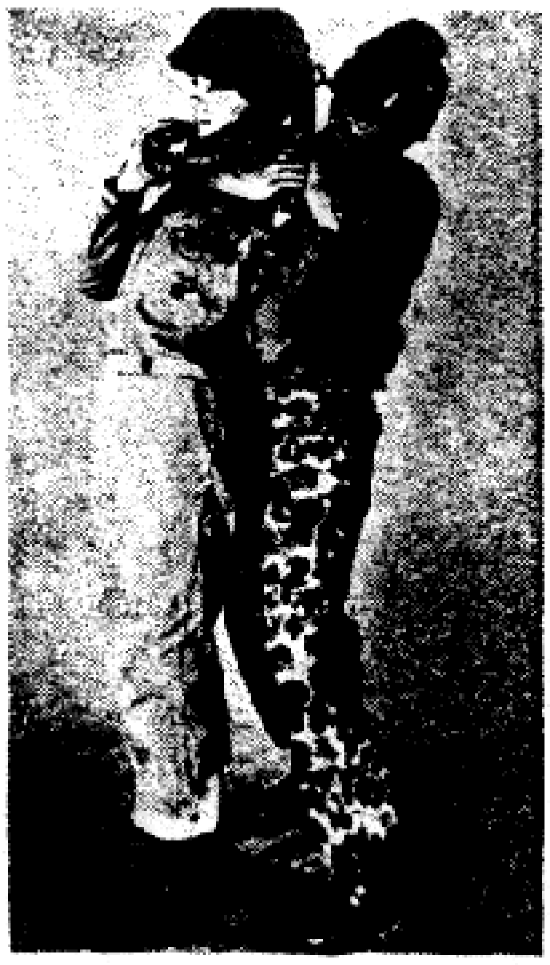

Figure 13.—Breaking rear neck hold.

left hand and upward with the right hand, at the same time pivoting his body to the left as he forces the opponent to twist down and over. He follows through with a knee blow or throw.

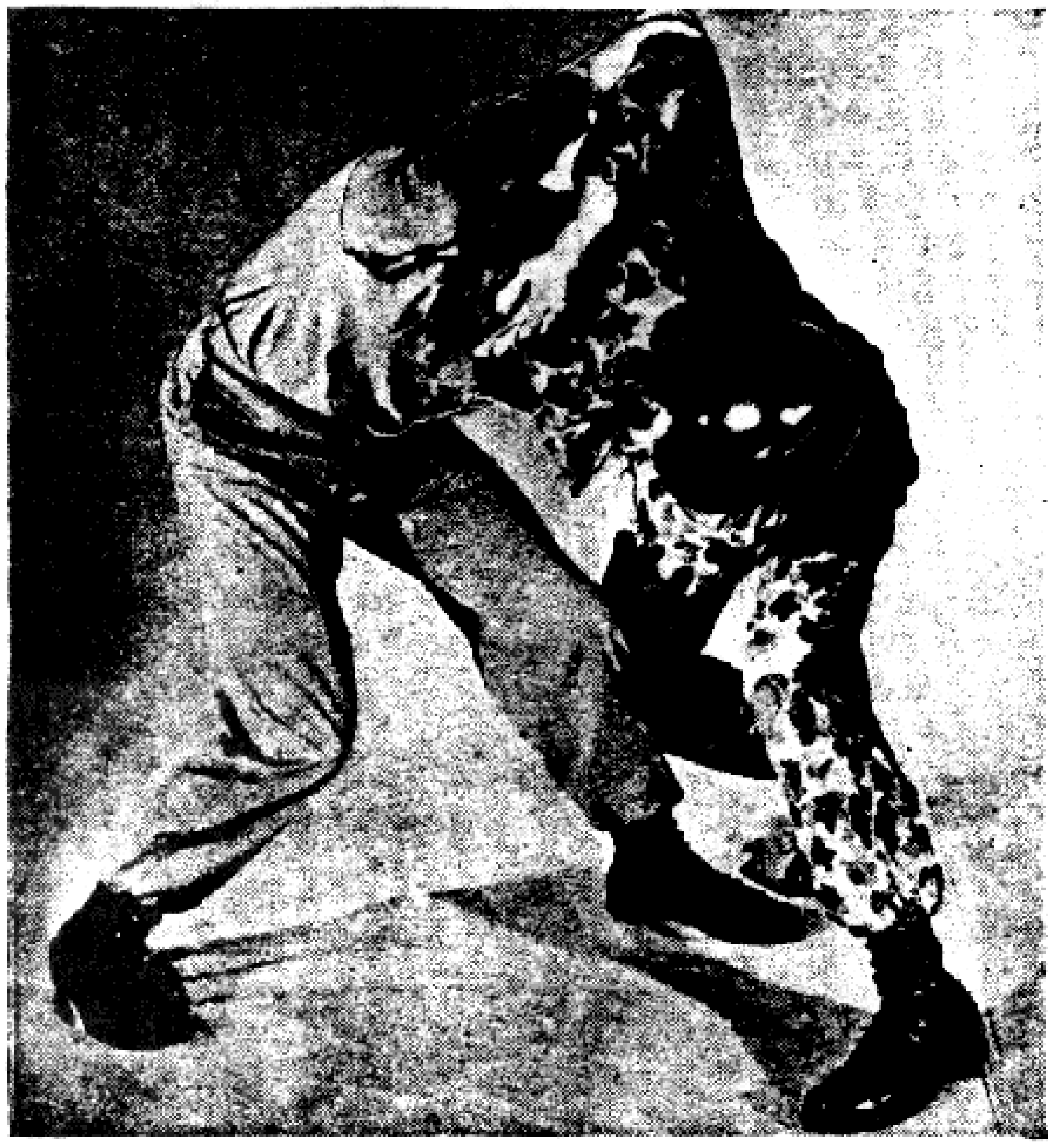

Figure 13.—Breaking rear neck hold.—(continued)

603. REAR CHOKE HOLD

To break a choke or strangle hold from the rear when the opponent is using one or both hands to make the hold, the hand-to-hand fighter grasps his opponent's left hand or wrist with his own left hand and pivots left still retaining the grip on his opponent's hand or wrist. He follows through with a blow to the opponent's temple, jaw, neck, or throat.

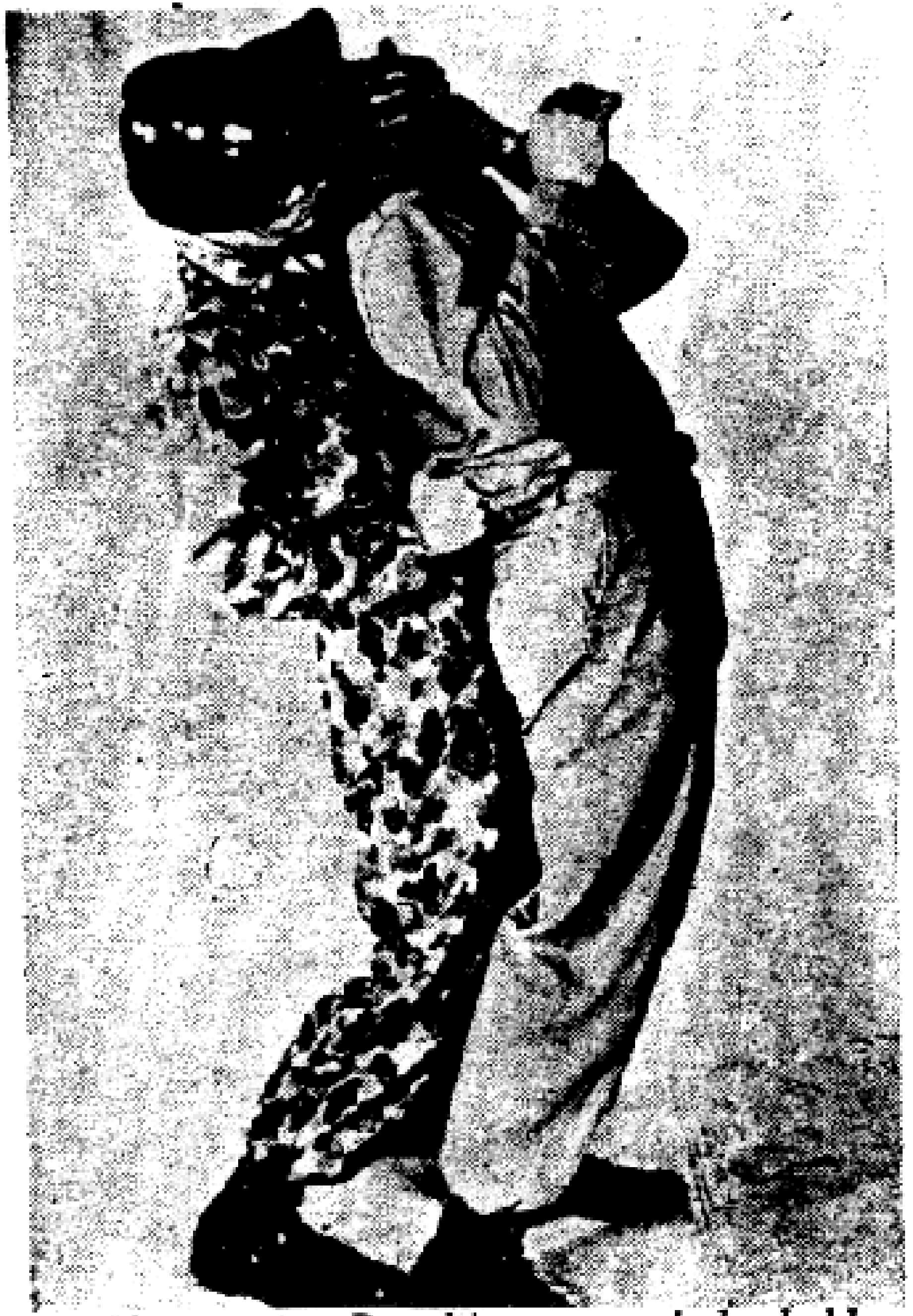

Figure 14.—Breaking rear choke hold.

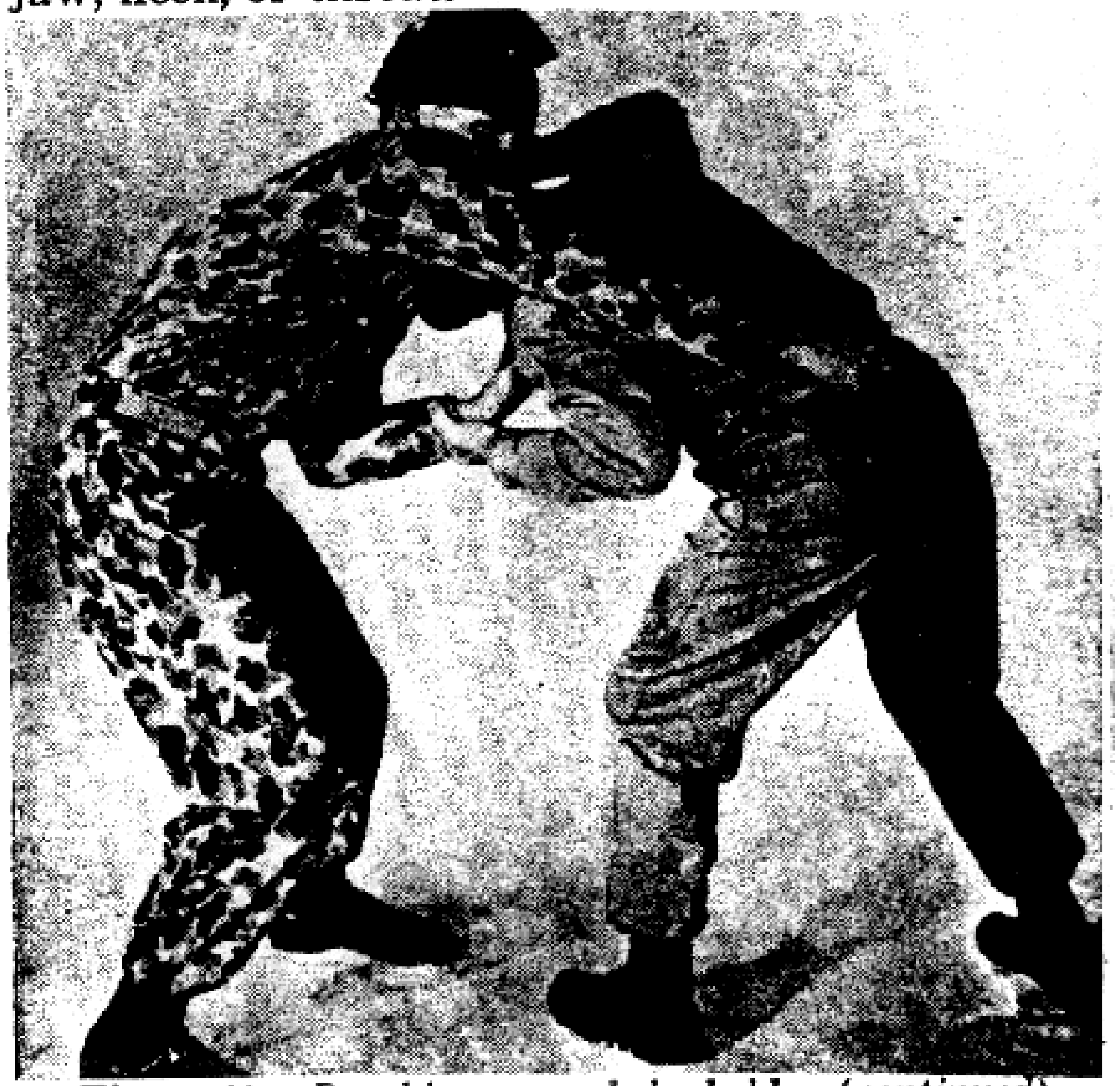

Figure 14.—Breaking rear choke hold.—(continued)

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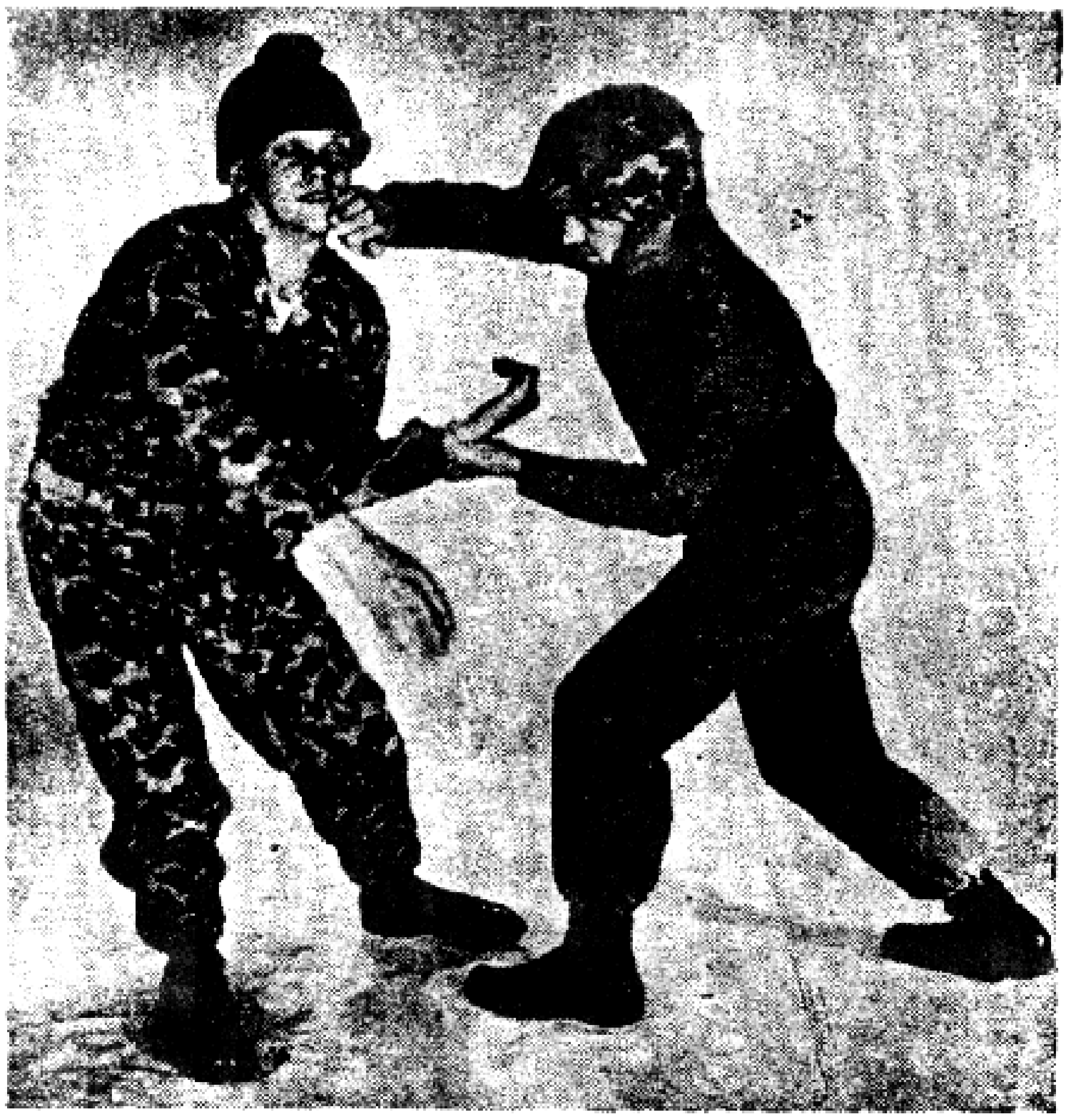

Figure 14.—Breaking rear choke hold.—(continued)

604. FRONT CHOKE HOLD

To break a front choke, collar, or tie hold, when the opponent is using either his right hand or both hands to make the hold, the hand-to-hand fighter grasps his opponent's right wrist or hand with his own left hand, then shifts left and pivots on his right foot, forcing his opponent's hand off and down to the right. He follows through with a blow to the opponent's temple, jaw, or throat.

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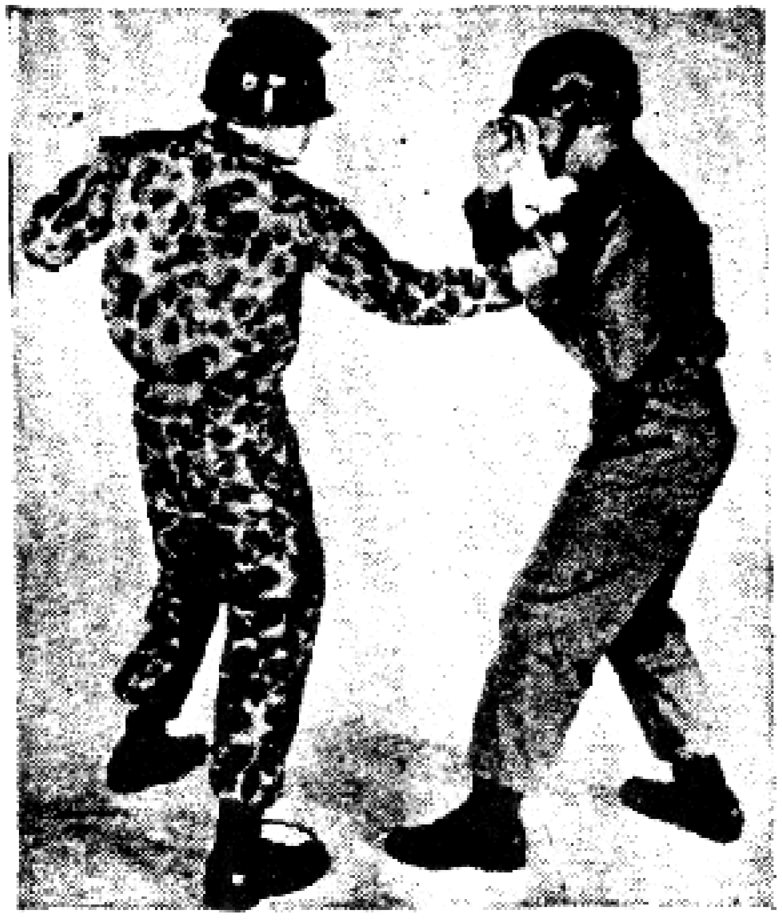
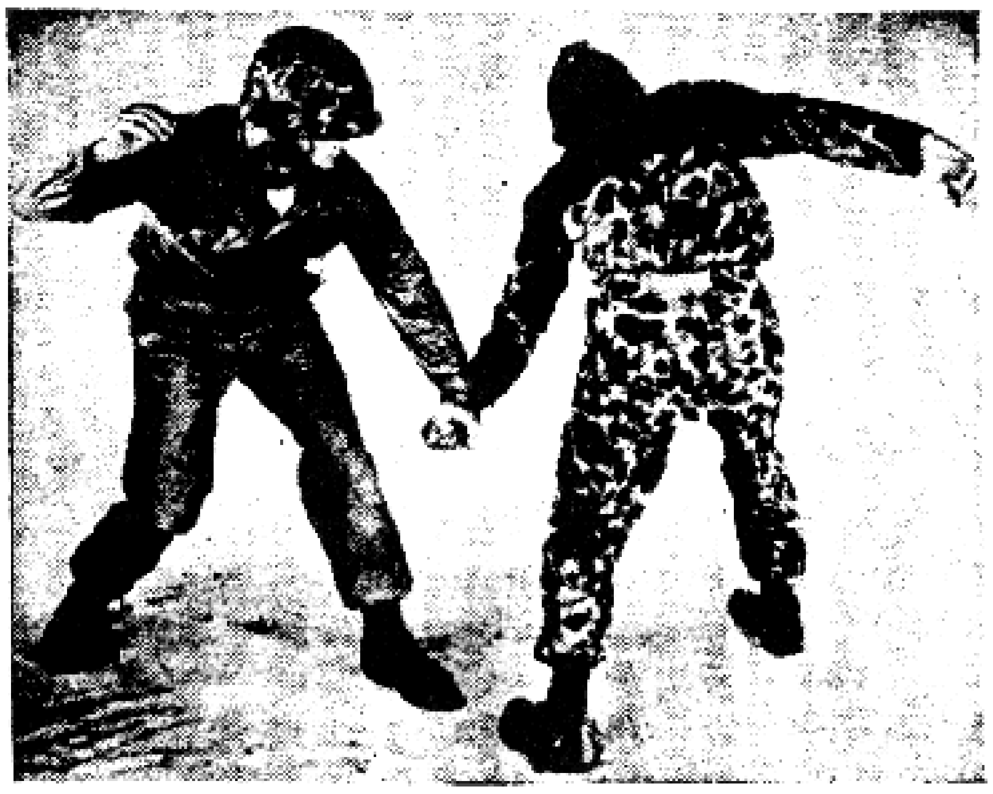


Figure 15.—Breaking front choke hold.



If the opponent is using his left hand to make the hold, the procedure is reversed.

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605. CROSSED WRIST FRONT CHOKE HOLD

To break a front choke hold when the opponent is using a crossed wrist collar choke, the hand-to-hand fighter grasps the opponent's right hand or wrist with his own right hand, shifts left

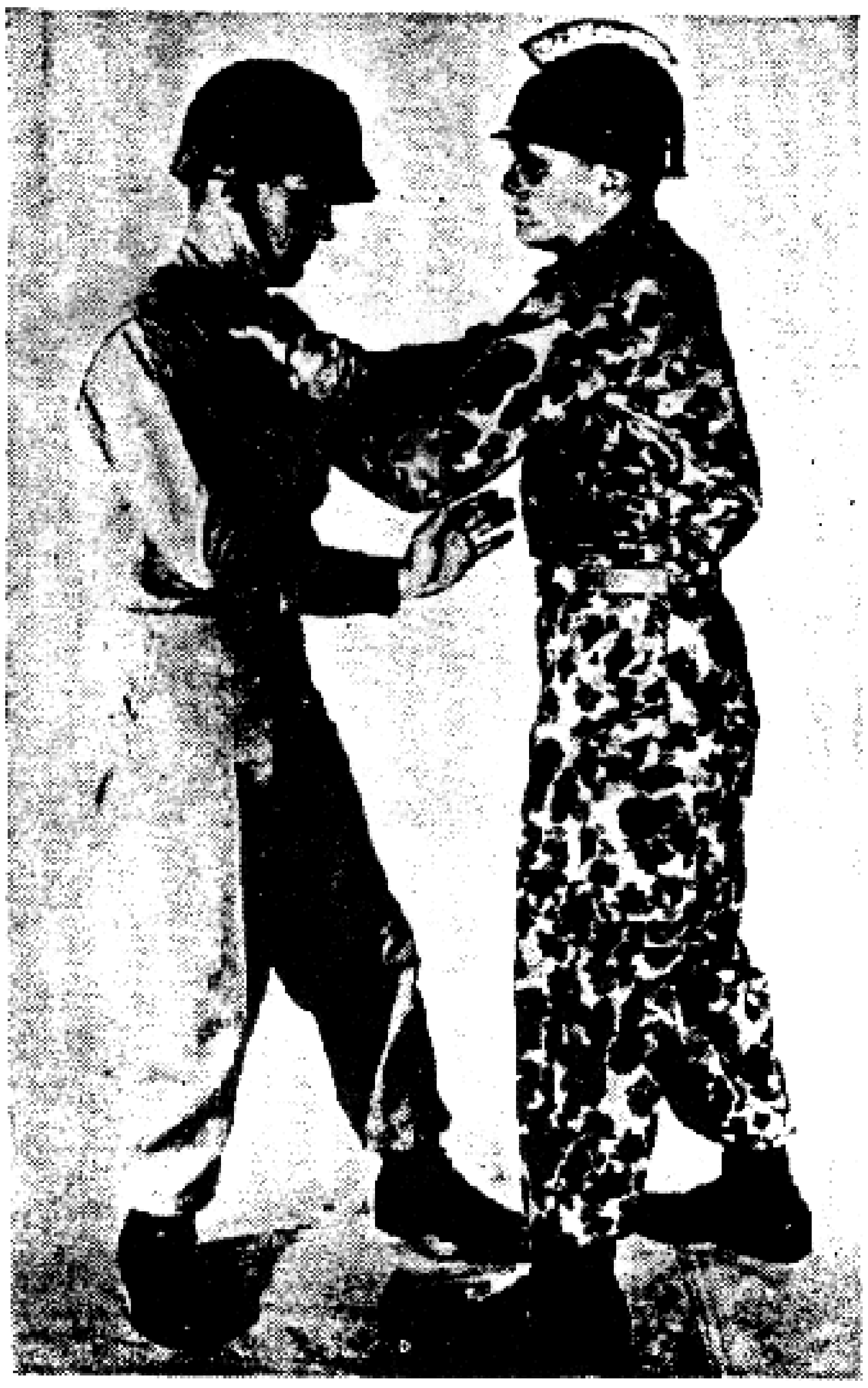

Figure 16.—Breaking crossed wrist front choke hold.

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and forward, pulling downward with his right hand, and lifting upward with the left hand which is placed on the opponent's right elbow. He follows through with a knee to the kidney, or a blow to the neck.

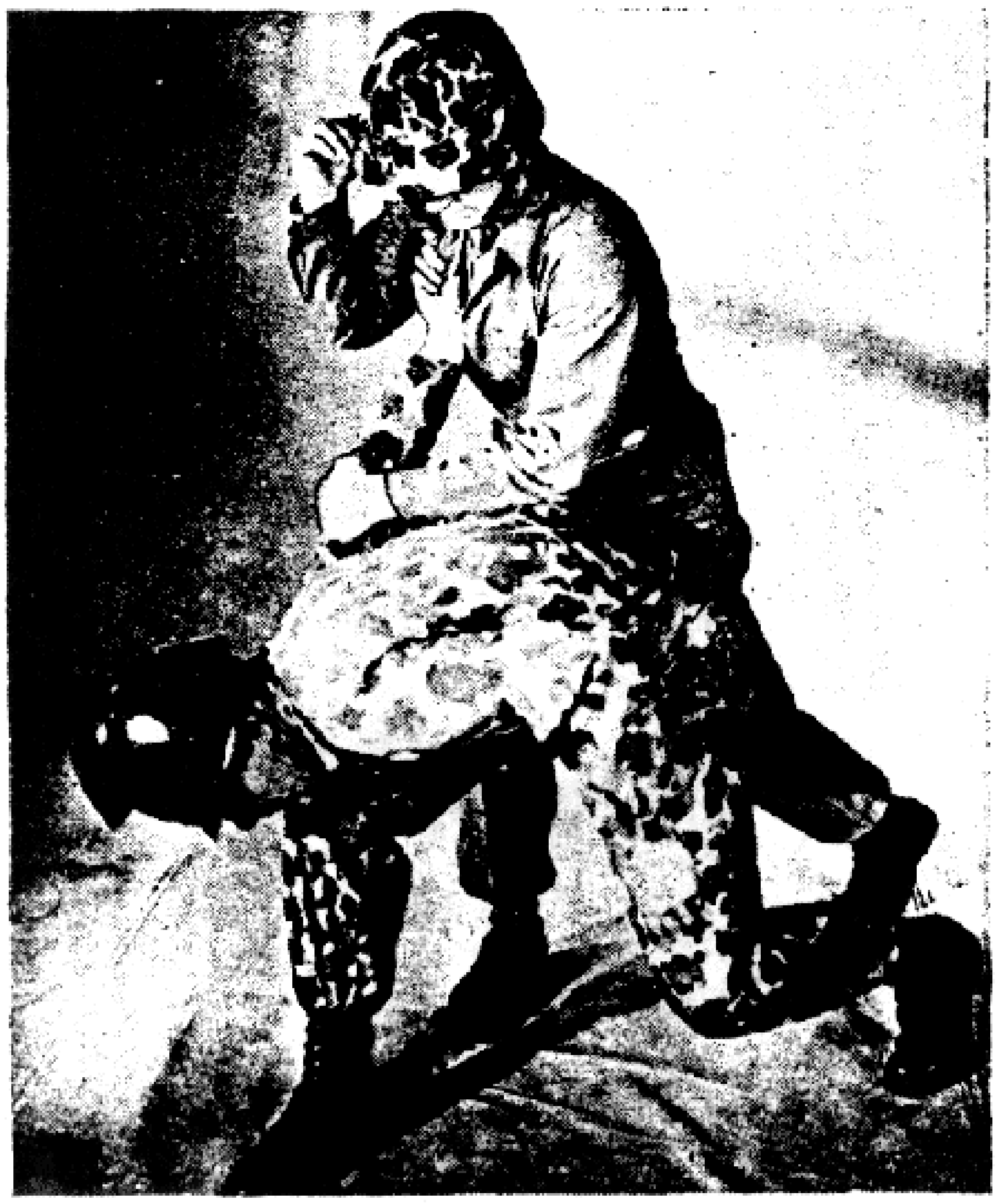

Figure 16.—Breaking crossed wrist front choke hold.—(continued)

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606. REAR HEAD LOCK

To break a head lock from the rear when the opponent is using one or both arms to hold the hand-to-hand fighter's head under his right arm the hand-to-hand fighter grasps the opponent's left elbow with his own left hand and the latter's left knee with his own right hand. He steps forward and left with his left foot, pulling right and upward, with the right hand forcing the opponent off balance and down on his side. He follows through with a blow to the temple or throat.

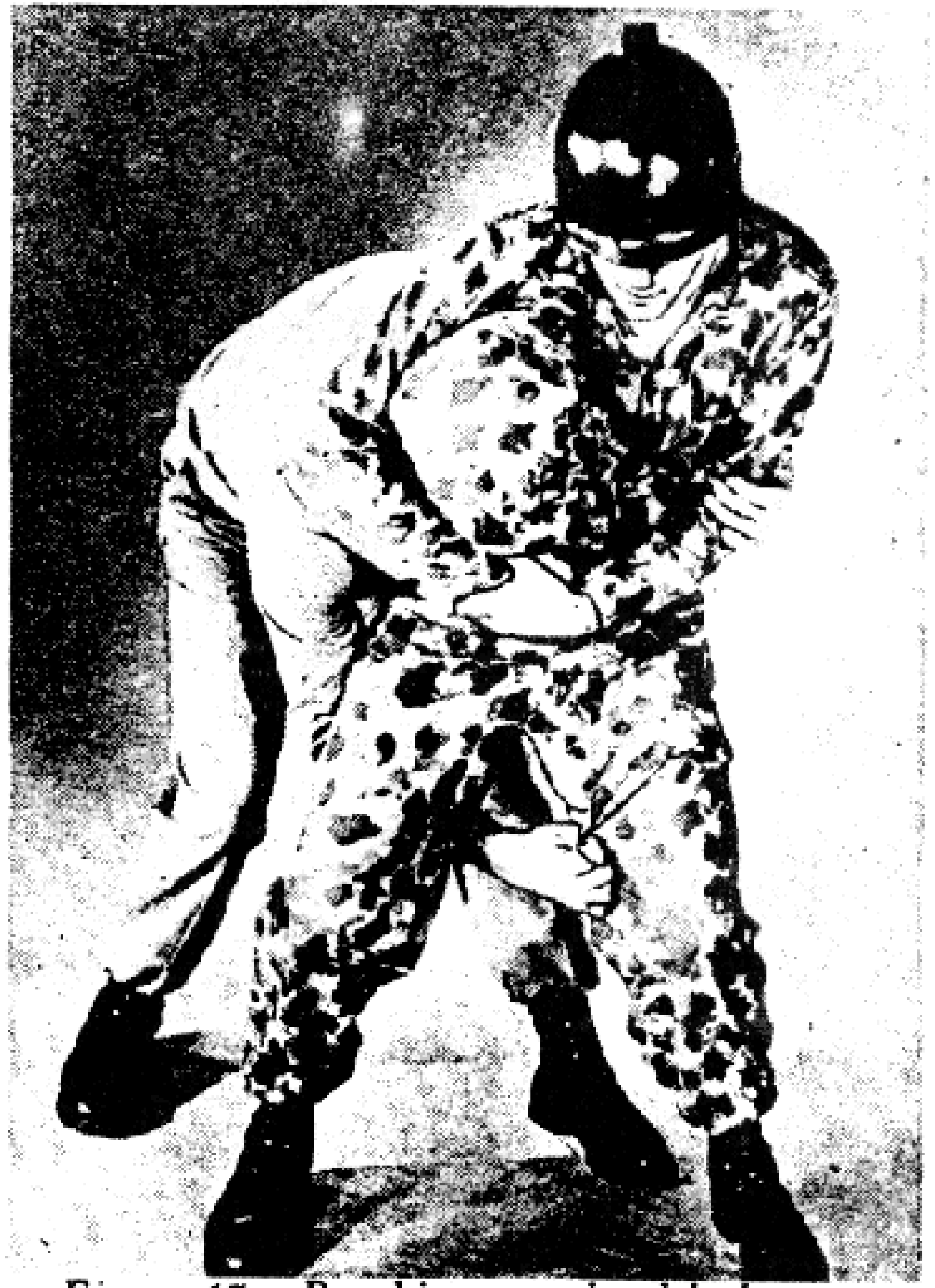

Figure 17.—Breaking rear head lock.

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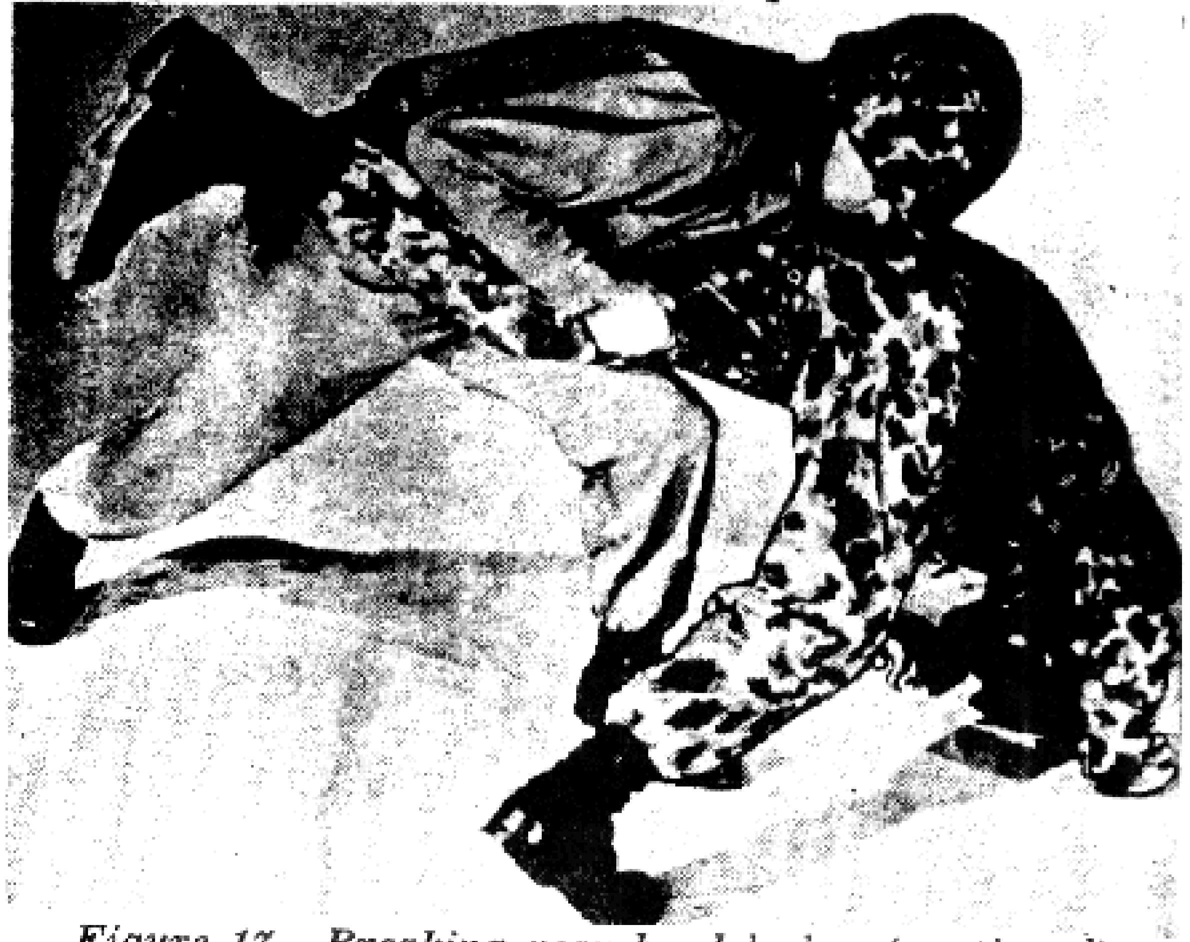


Figure 17.—Breaking rear head lock.—(continued)

607. FRONT HEAD LOCK

To break a front head lock when the opponent is locking a hand on the hand-to-hand fighter's right shoulder, the hand-to-hand fighter slides his right hand and arm over his opponent's right elbow with his left hand. He pushes down with his right shoulder and pivots left forcing the opponent to break the hold. He follows through with a throw or blow to his opponent's groin, or breaks his right arm.

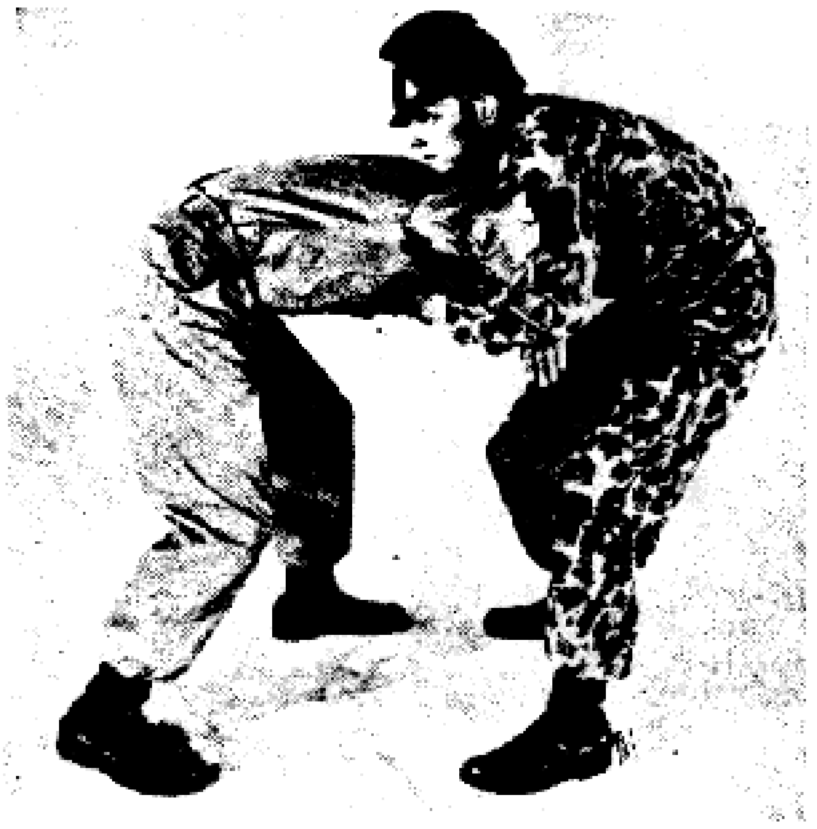
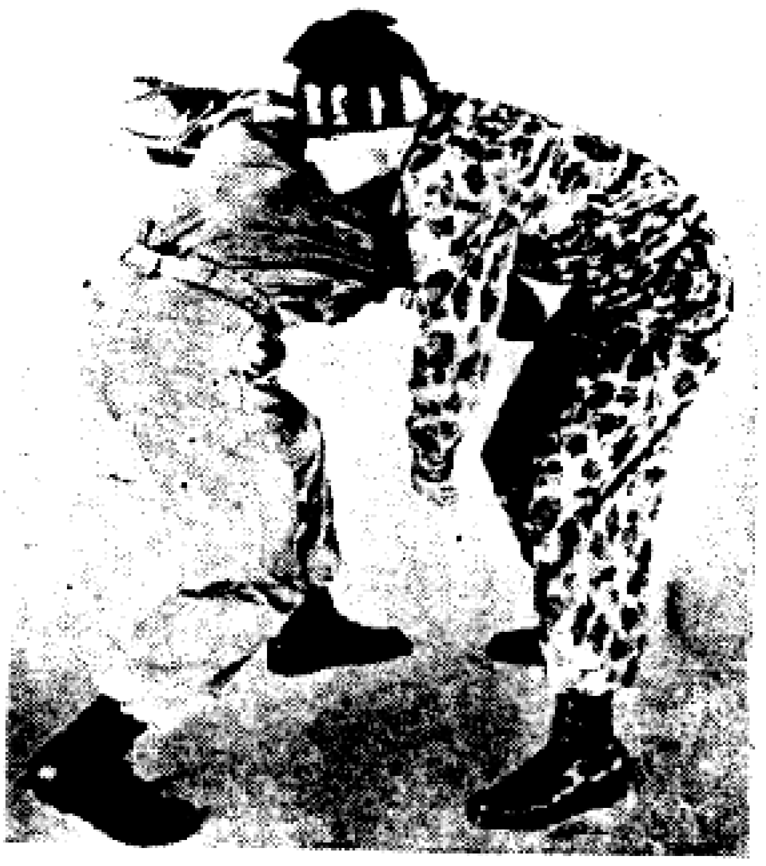


Figure 18.—Breaking front head lock.



608. THE HAMMERLOCK

To break a hammerlock and shoulder hold when the opponent is holding the hand-to-hand fighter's hand behind him, the hand-to-hand fighter steps forward with the right foot, bends his body forward from the waist, then rapidly twists to the left breaking the hold. He follows through with a blow to the opponent's temple, jaw, or kidney.

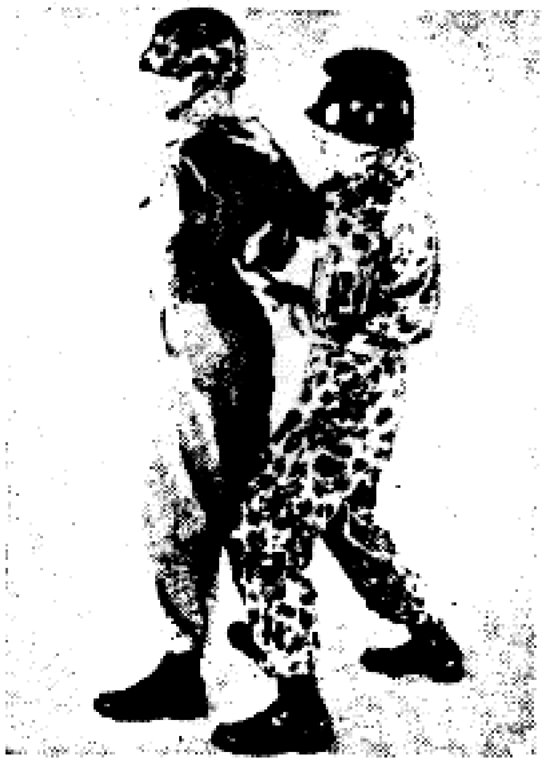
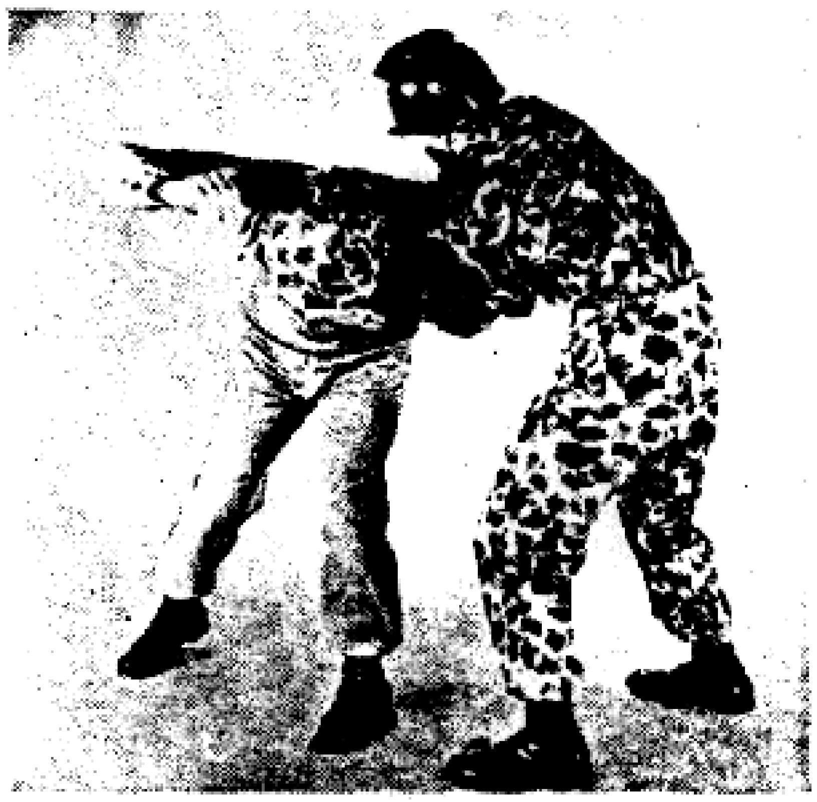
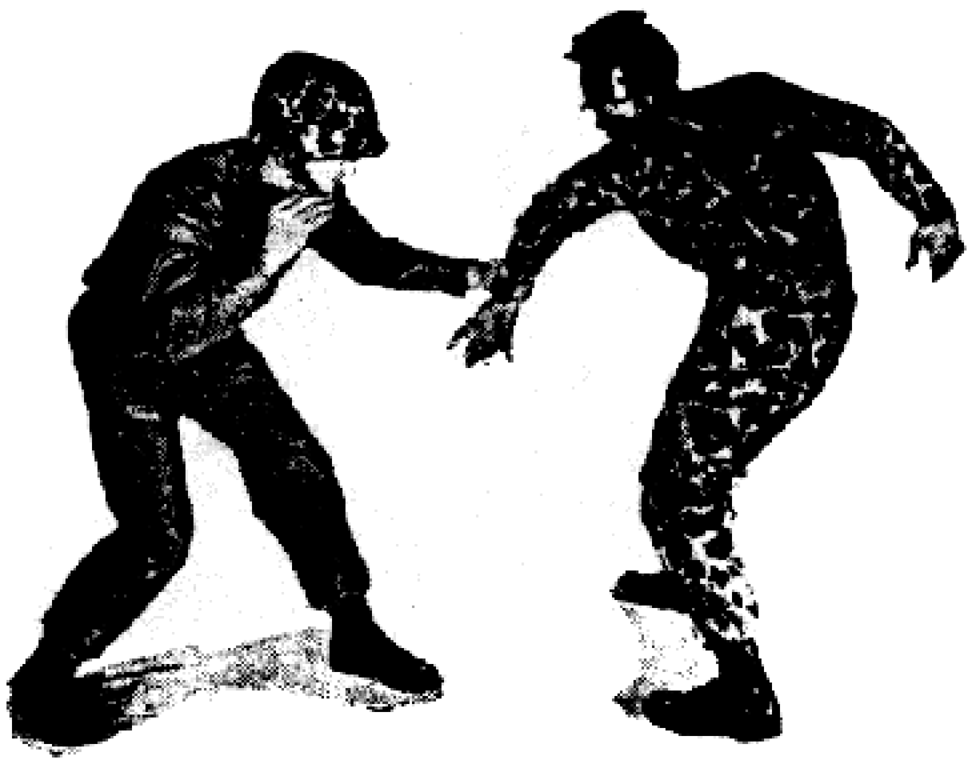


Figure 19.—Breaking the hammerlock





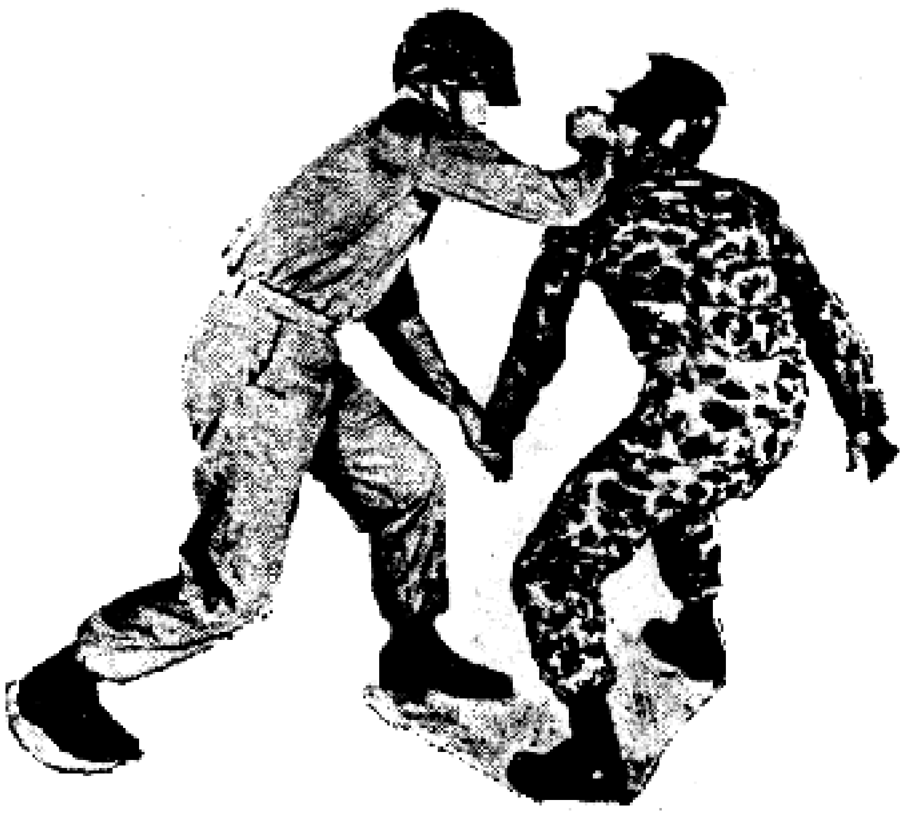


Figure 19.—Breaking the hammerlock.—(continued)

609. COME–ALONG

To break a come–along hold when the opponent is using any of the various come–along holds, i. e., bending fingers downward or hand upward, the hand-to-hand fighter lifts upward with the free hand placed against the opponent's hand, or hands. At the same time he drives his right knee into the back of his opponent's left knee, forcing the opponent to break the hold and knocking him over on his back. He follows through with a knee, or a blow to the bridge of the nose or throat. In the event the opponent is holding the left hand and arm, the hand-to-hand fighter uses his left knee against his opponent's left knee to knock him over and down.

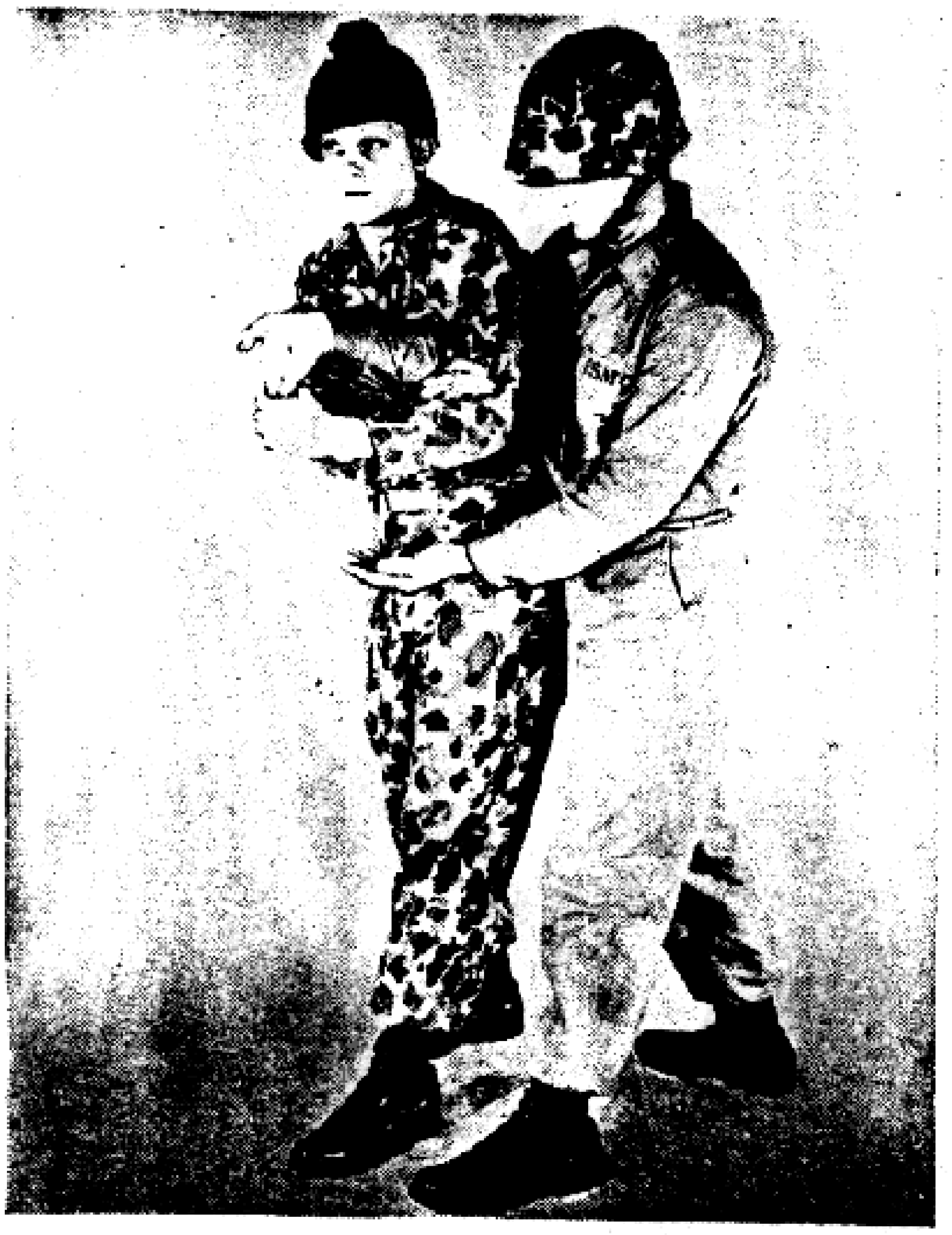


Figure 20.—Breaking a finger bending come–along.

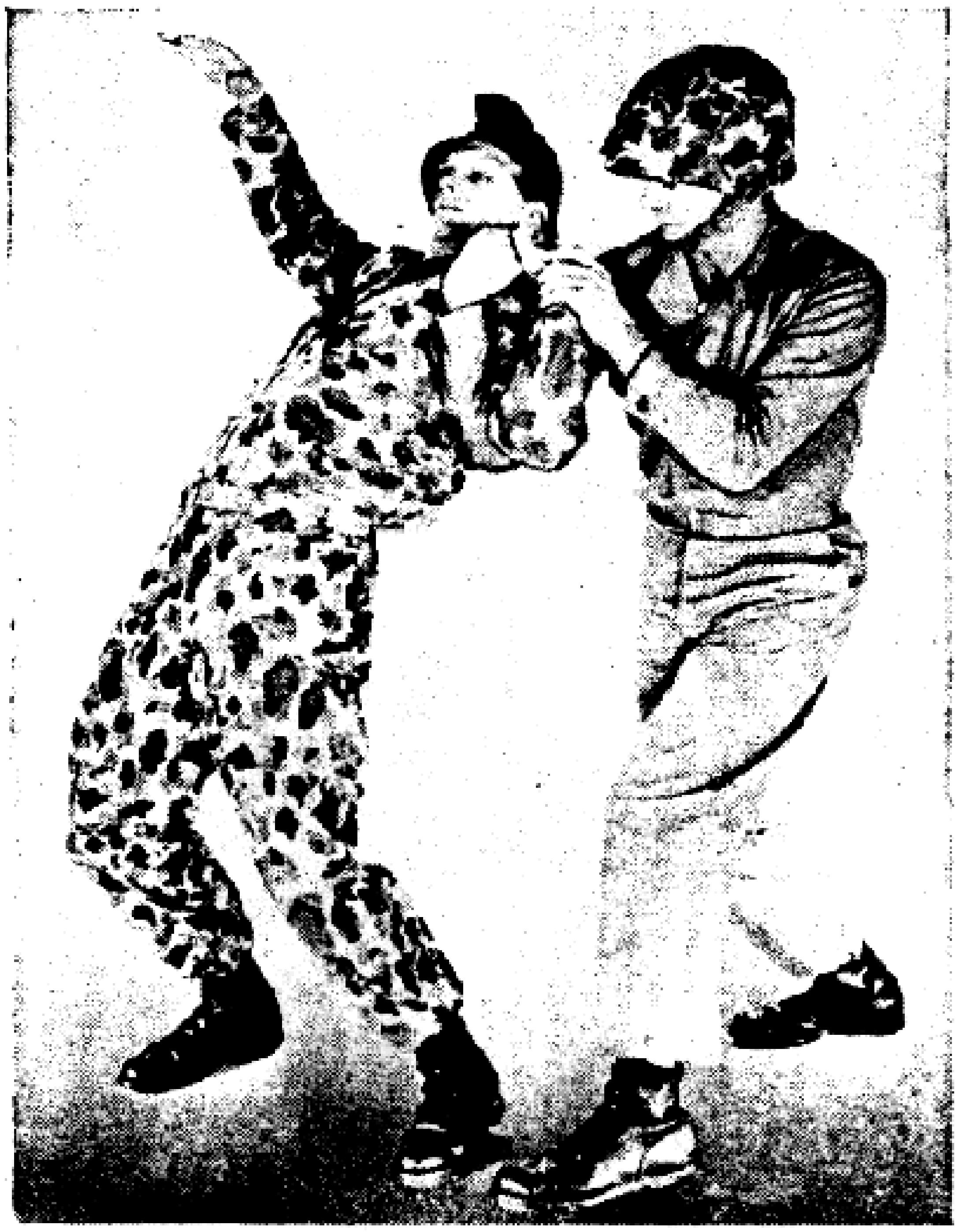


Figure 20.—Breaking a finger bending come–along.—(continued)

Section 7

DISARMING AN OPPONENT ARMED WITH A RIFLE AND BAYONET

701. SLOW APPROACH - BAYONET LOW

To disarm an opponent armed with a rifle with fixed bayonet who approaches slowly with the weapon held low, the hand-to-hand fighter sidesteps, reaches forward and down with the left hand hitting the opponent's weapon on the inside, and with a pushing movement deflects the bayonet

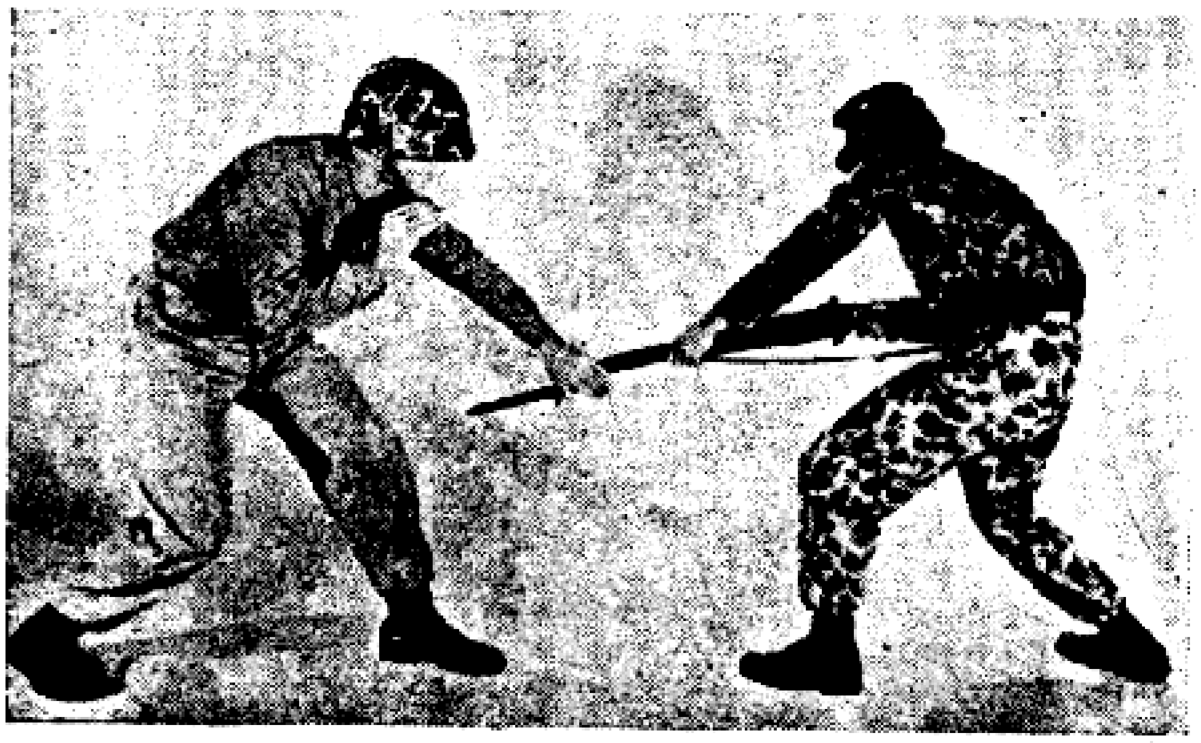


Figure 21.—Disarming slowly approaching opponent armed with fixed bayonet held low.

off to the left. He then shifts right and forward, delivering a blow to the temple, neck, or the left elbow of his opponent.

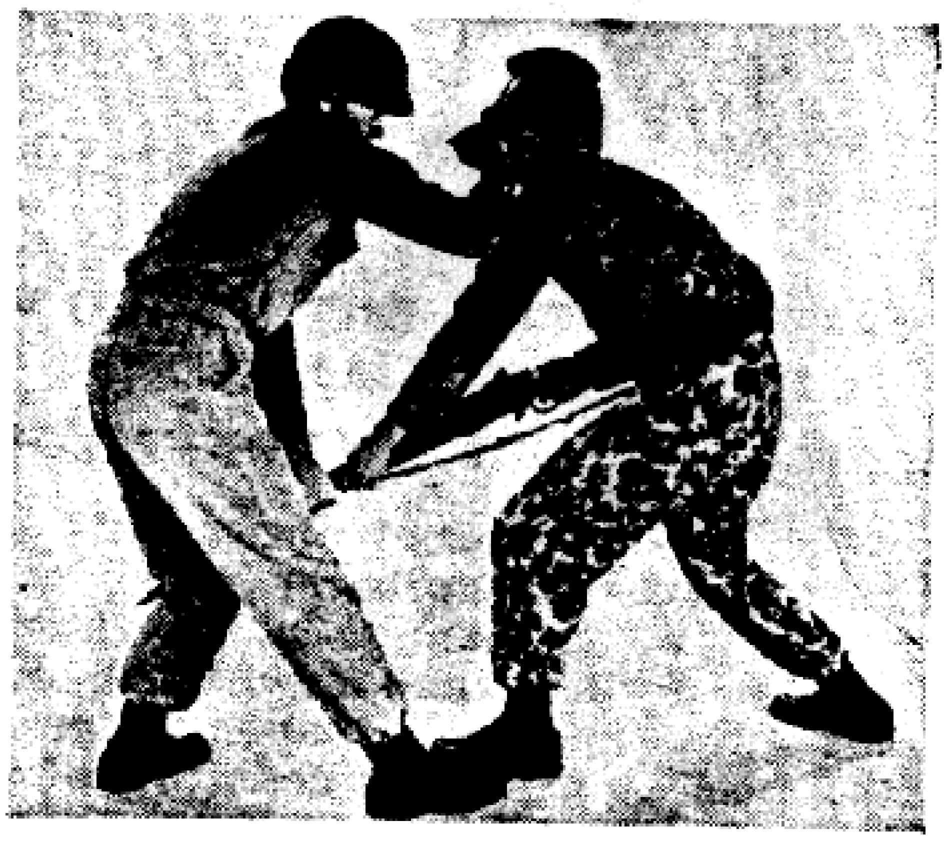
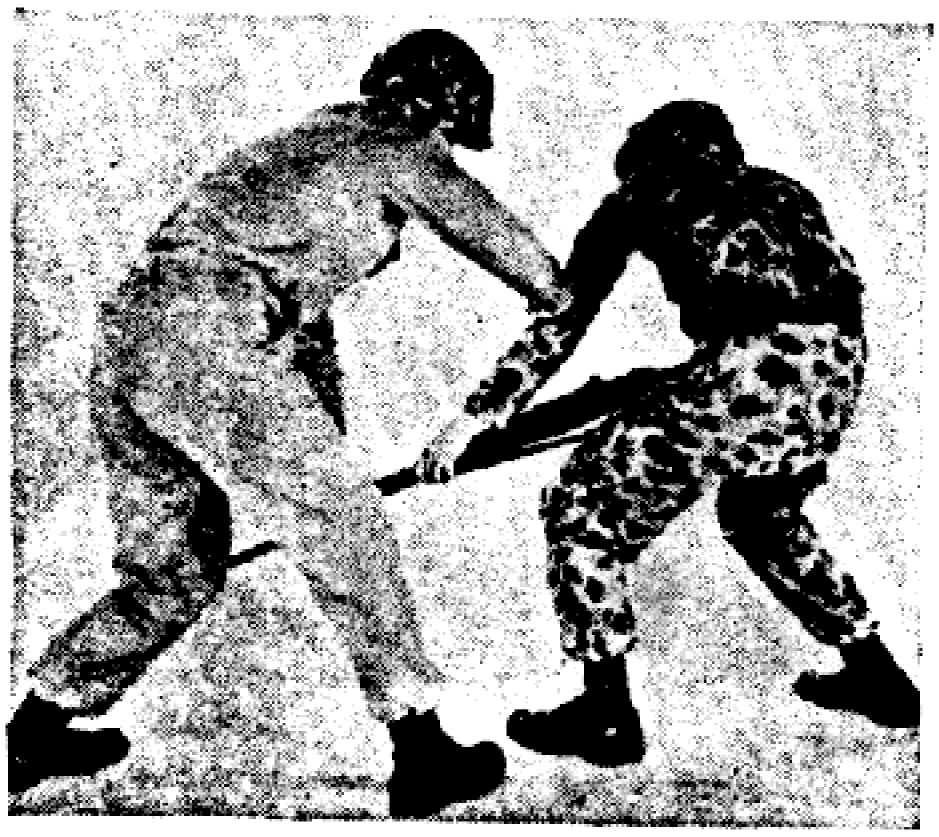


Figure 21.—Disarming slowly approaching opponent armed with fixed bayonet held low.—(continued)



702. SLOW APPROACH - BAYONET HIGH

To disarm an opponent armed with a rifle with fixed bayonet who approaches slowly with the weapon held high, the hand-to-hand fighter reaches out with his left hand and hits the weapon and pushes it to the left, deflecting the blow. He

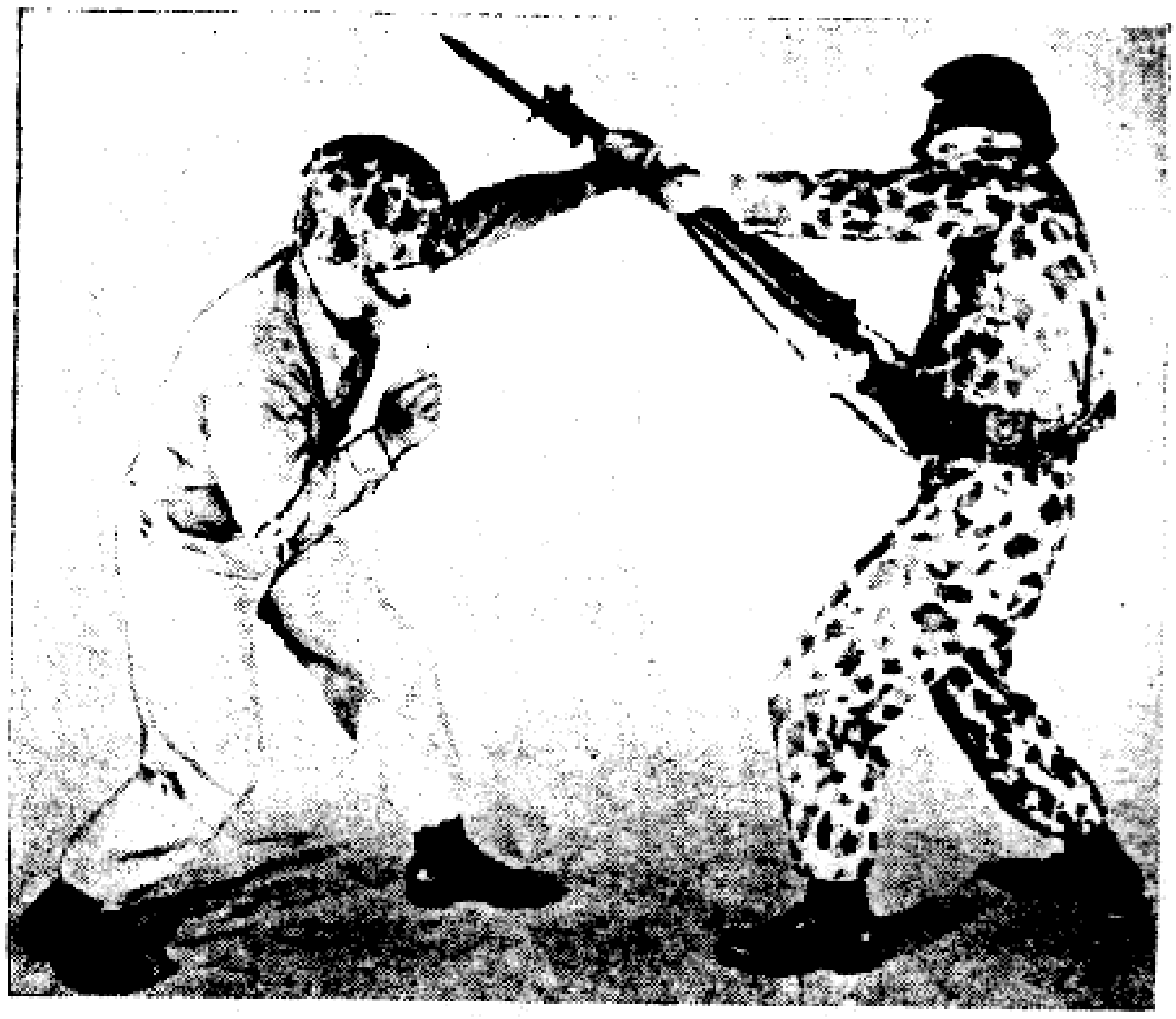


Figure 22.—Disarming slowly approaching opponent armed with fixed bayonet held high.

then quickly shifts right and forward, reaching forward with the right hand grasping the rifle near the stock and wrests it from his opponent. He follows through with a blow to the opponent's elbow, temple, or neck.

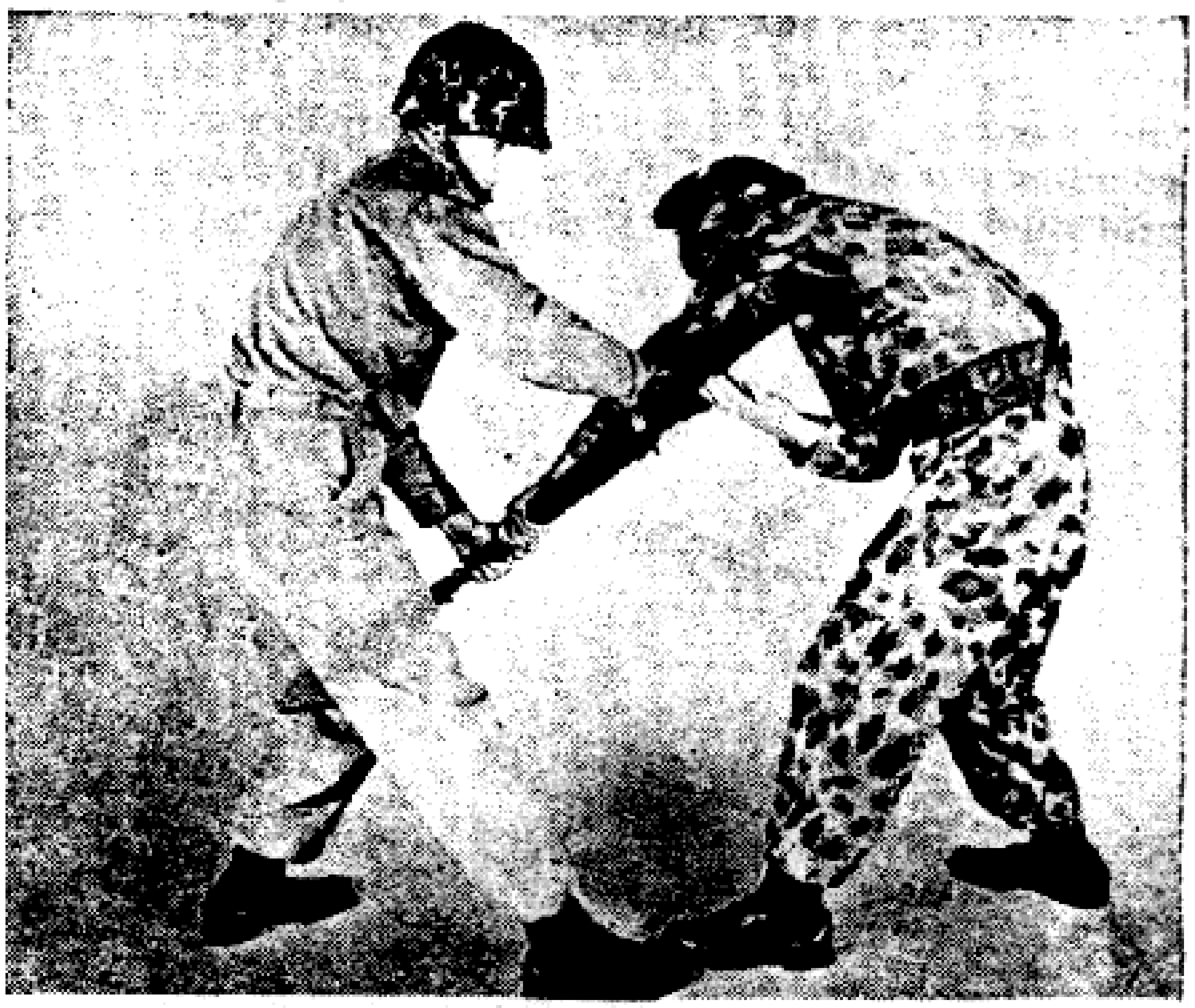


Figure 22.—Disarming slowly approaching opponent armed with fixed bayonet held high.—(continued)

703. CHARGING OPPONENT

To disarm an opponent armed with a rifle and bayonet who is charging rapidly forward toward him, the hand-to-hand fighter shifts left and forward to avoid the bayonet. He then hits and pushes the weapon downward and to the right with his left hand. He follows through with a blow to his opponent's neck.

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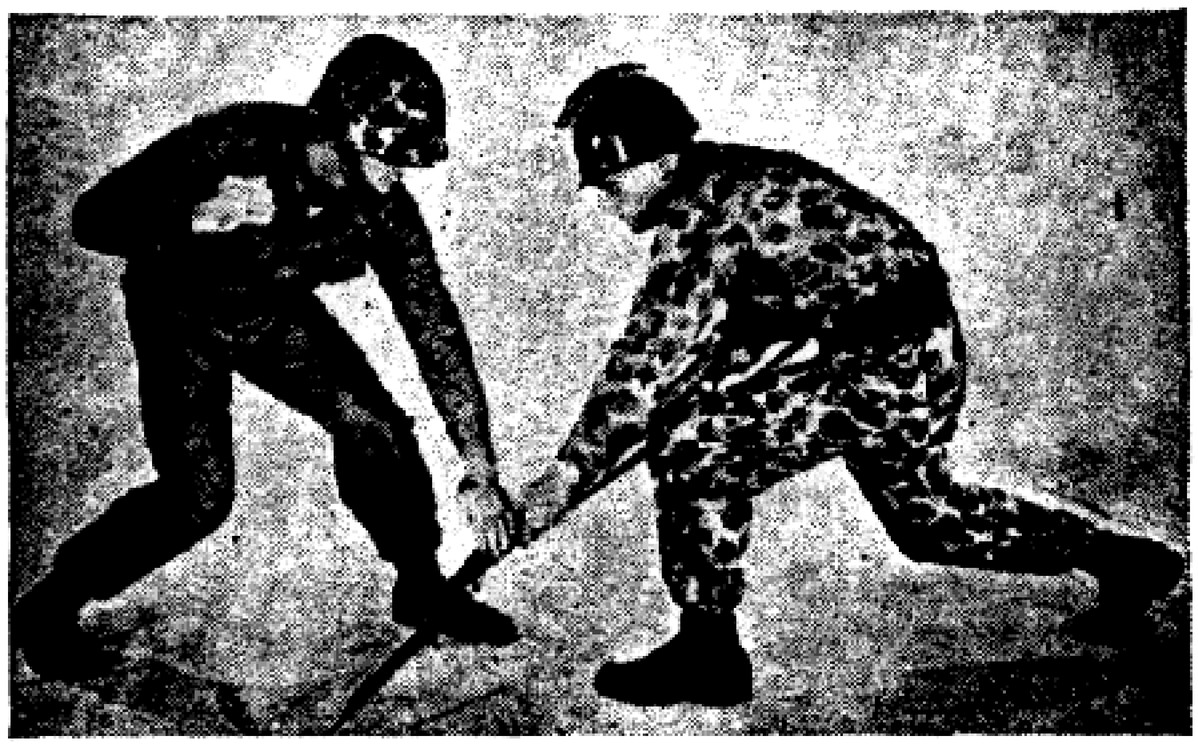
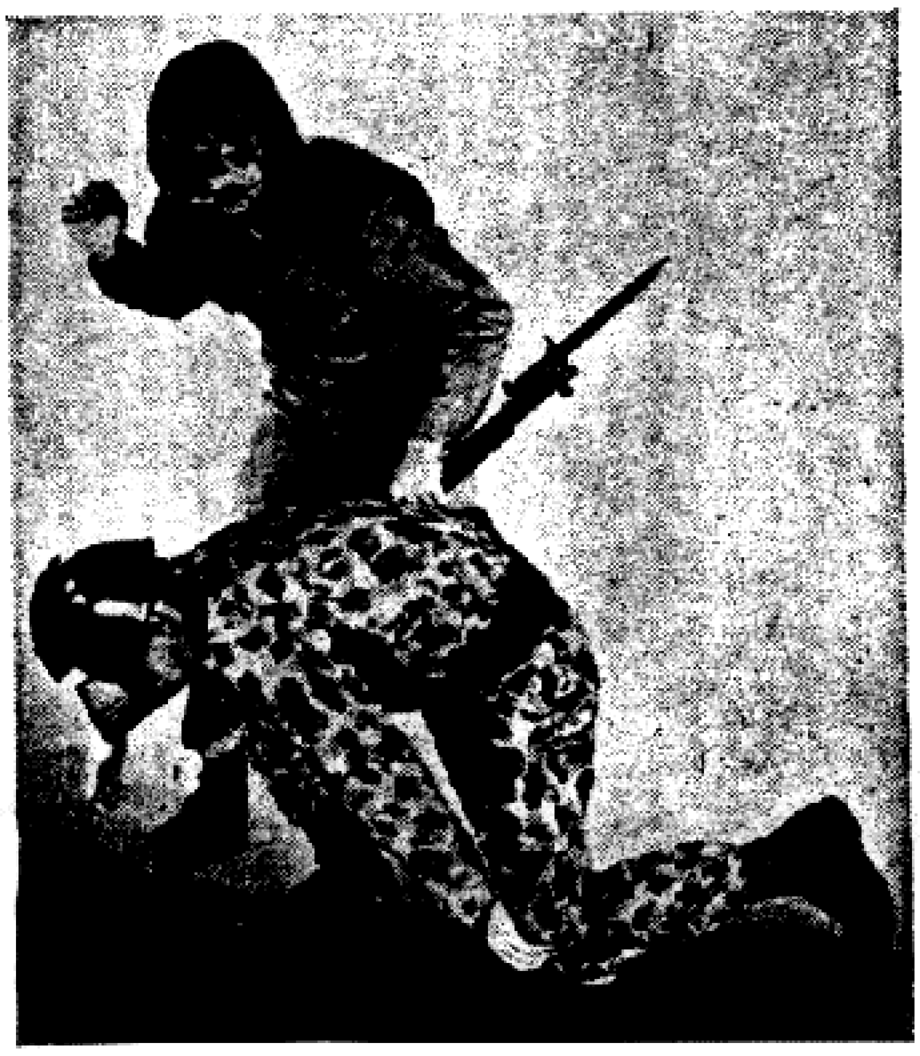


Figure 23.—Disarming charging opponent armed with fixed bayonet.



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Section 8

KNIFE AND CLUB FIGHTING

801. FRONTAL ATTACK WITH THE KNIFE

When attacking while armed with a knife, the hand-to-hand fighter assumes the OFFENSIVE–DEFENSIVE STANCE, holds the knife in his right hand with the point toward the opponent, the blade flat, and the cutting edge facing outward.

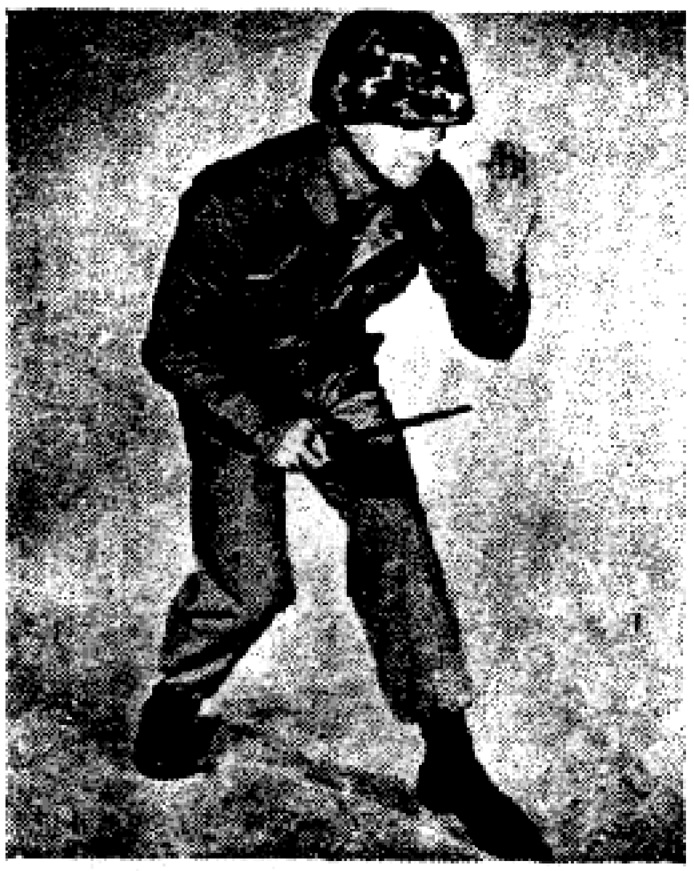

Figure 24.—Frontal attack with knife.

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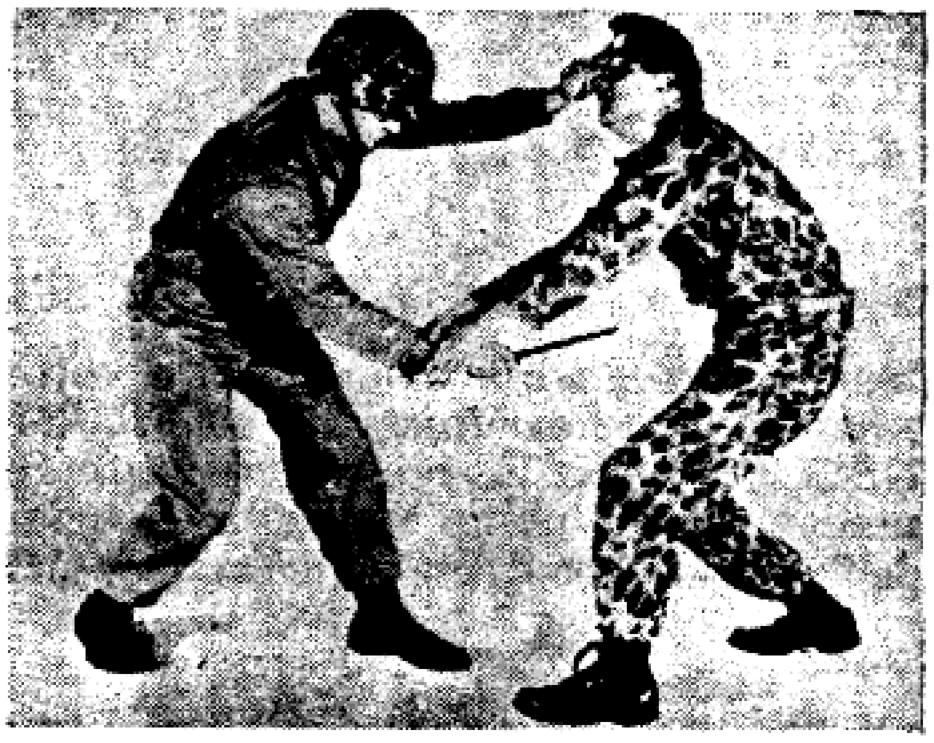
He advances toward the opponent, his left hand held high in an alert position to protect his face or to deliver a blow. If the opponent attempts to grasp the knife hand, the hand-to-hand fighter strikes a blow at the bridge of the nose. He then



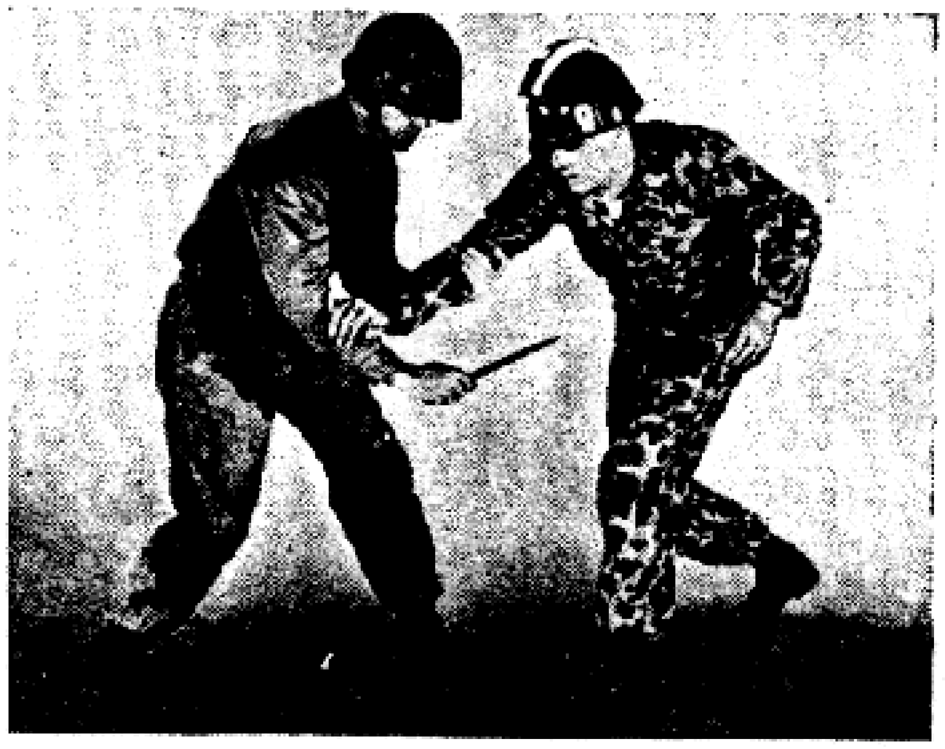


Figure 24.—Frontal attack with knife.—(continued)

shifts left, places his left hand under his opponent's right elbow, and lifts the arm. He plunges the knife in an upward motion into the body above the opponent's belt, and slashes outward, or to the right.

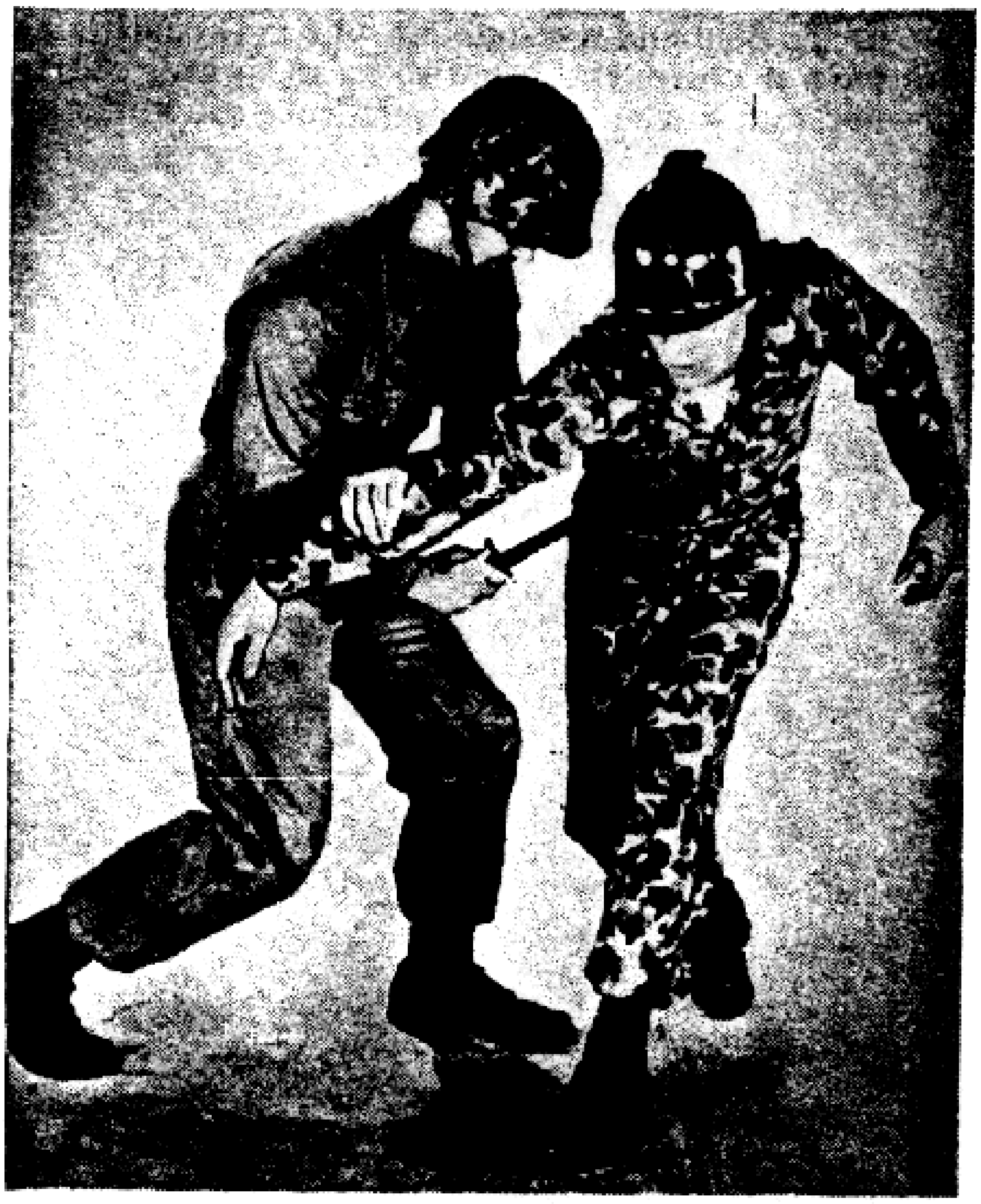


Figure 24.—Frontal attack with knife.—(continued)

802. FRONTAL DISARMING - OPPONENT WITH KNIFE OR CLUB

a. To disarm an opponent who is thrusting at him with a knife, the hand-to-hand fighter shifts forward and to the left. He deflects the knife by pushing it with his left hand. He then strikes the back of the opponent's hand with the outer edge of his own right hand. He follows through with an arm break, or blow to the opponent's jaw, throat, or collarbone.

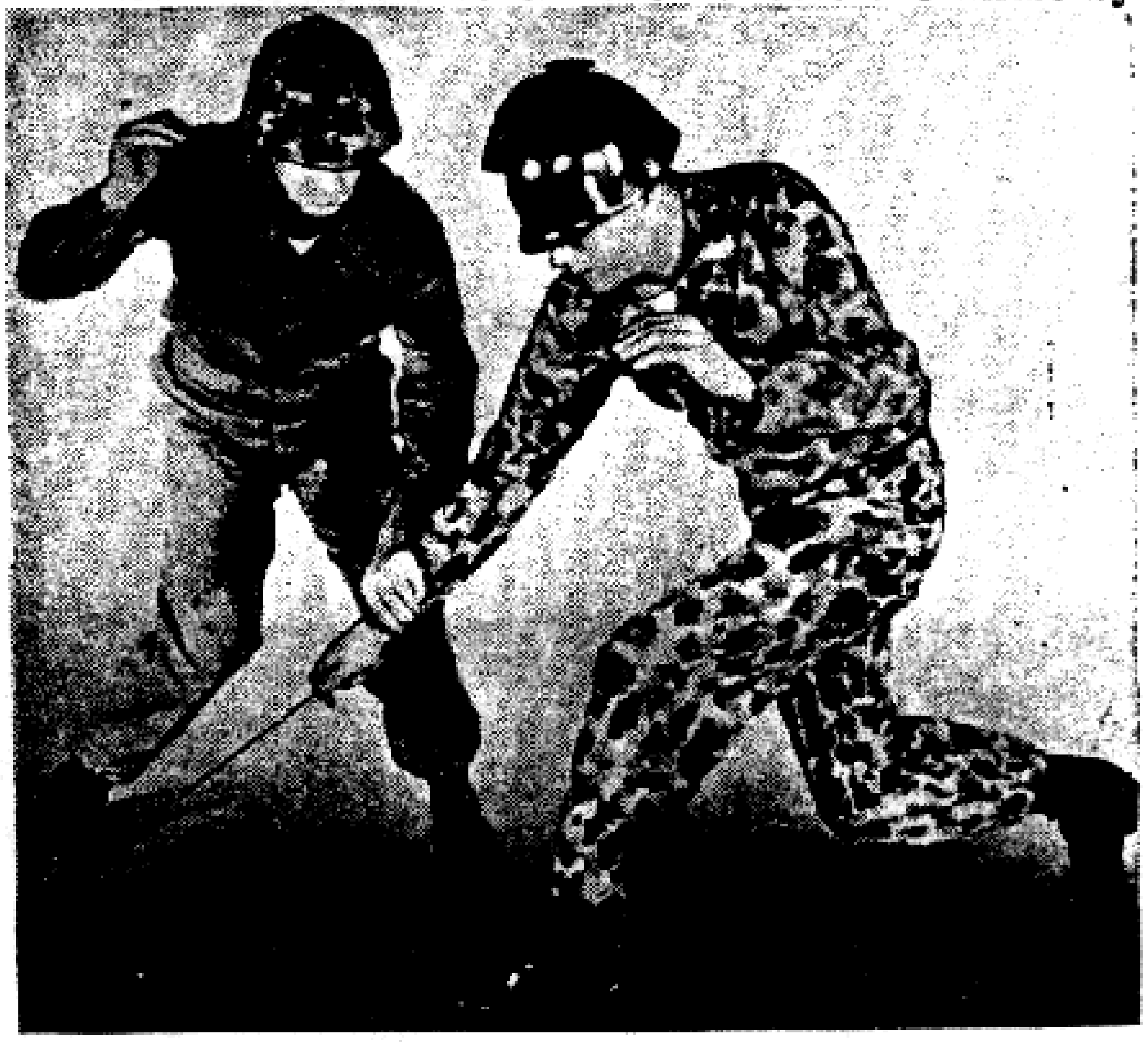


Figure 25.—Frontal disarming - opponent with knife.

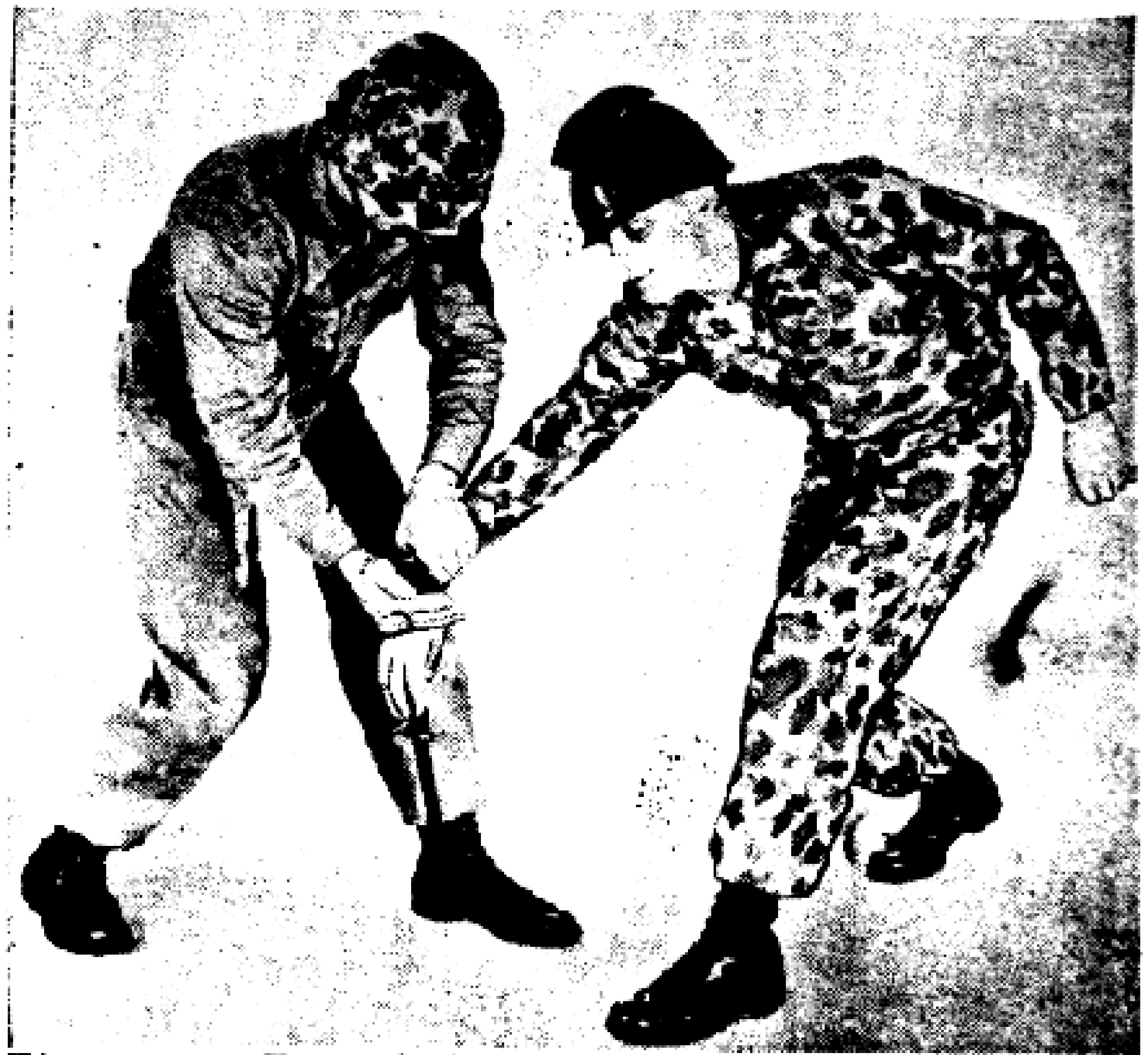


Figure 25.—Frontal disarming - opponent with knife.—(continued)

b. In another method of disarming, when the opponent threatens with a knife or club, the hand-to-hand fighter steps toward his opponent with his left foot. He strikes the inside of his opponent's right wrist with his own left hand or wrist deflecting the thrust off to the left. He then strikes the opponent on the bridge of the nose with the right hand, and simultaneously strikes him in the groin with the right knee. He can follow through by breaking the opponent's arm, or by employing a throw.

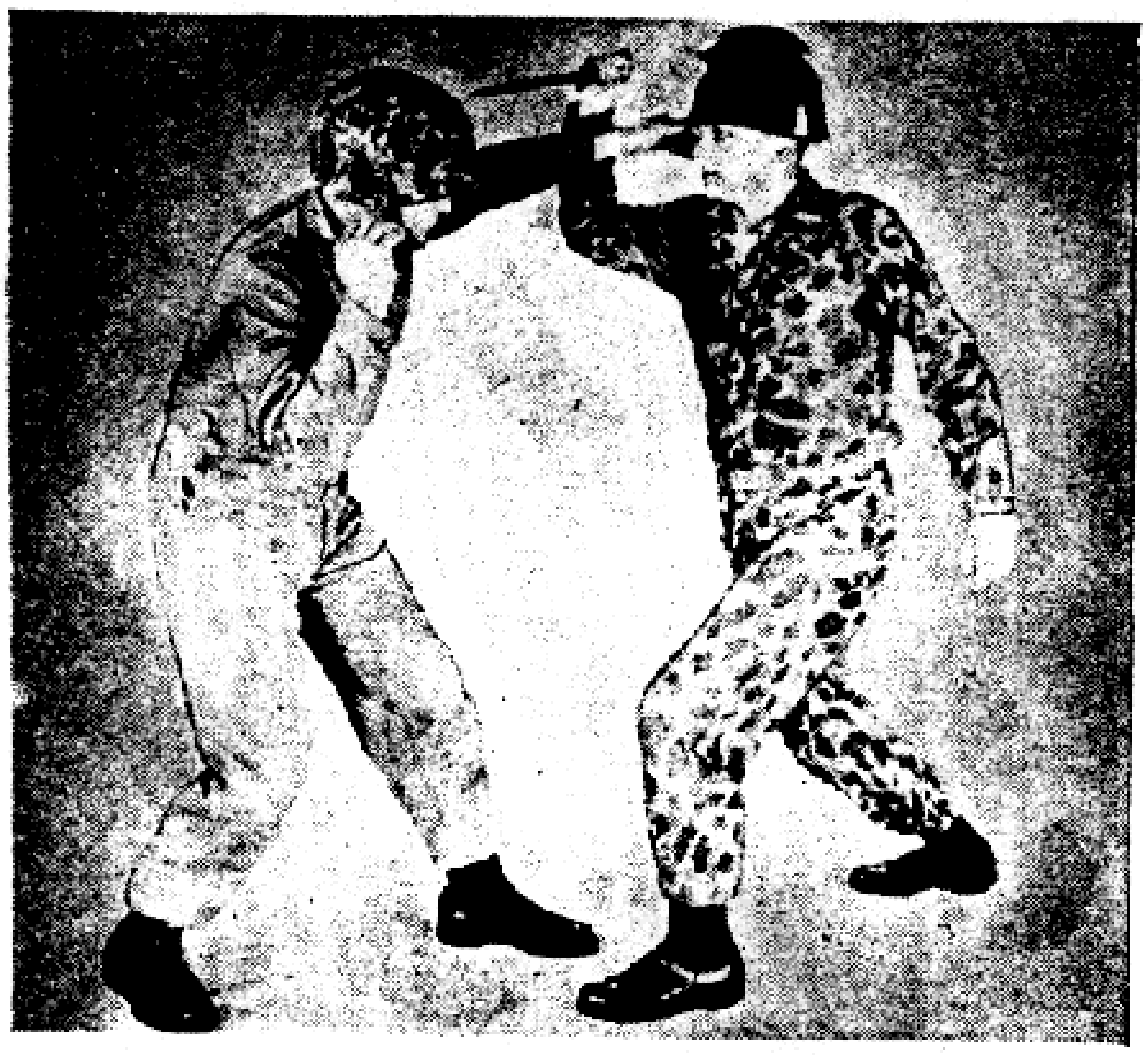


Figure 26.—Frontal disarming – opponent with knife or club.

803. ATTACK FROM THE REAR WITH KNIFE OR CLUB

a. In attacking an opponent from the rear when armed with a knife, the hand-to-hand fighter quickly places a hand over the mouth and face of the opponent and pulls back, simultaneously plunging the knife in an upward motion into the opponent's back above the belt.

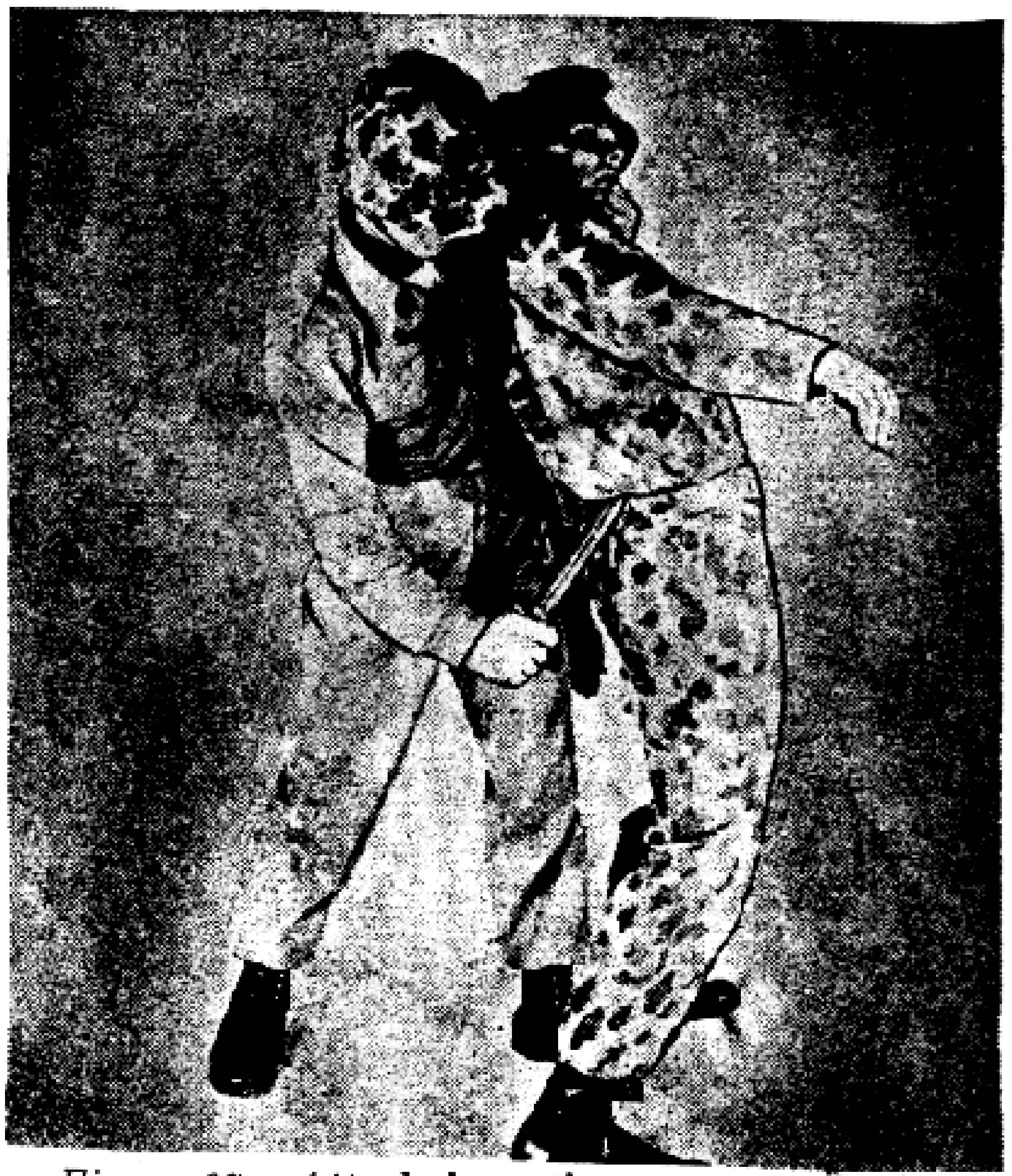


Figure 27.—Attack from the rear using knife.

b. In attacking an opponent from the rear while armed with a club, the hand-to-hand fighter controls his opponent by placing his left hand on the opponent's arm or shoulder, and turning him slightly to the left. The blow, or blows are delivered to the base of the skull.

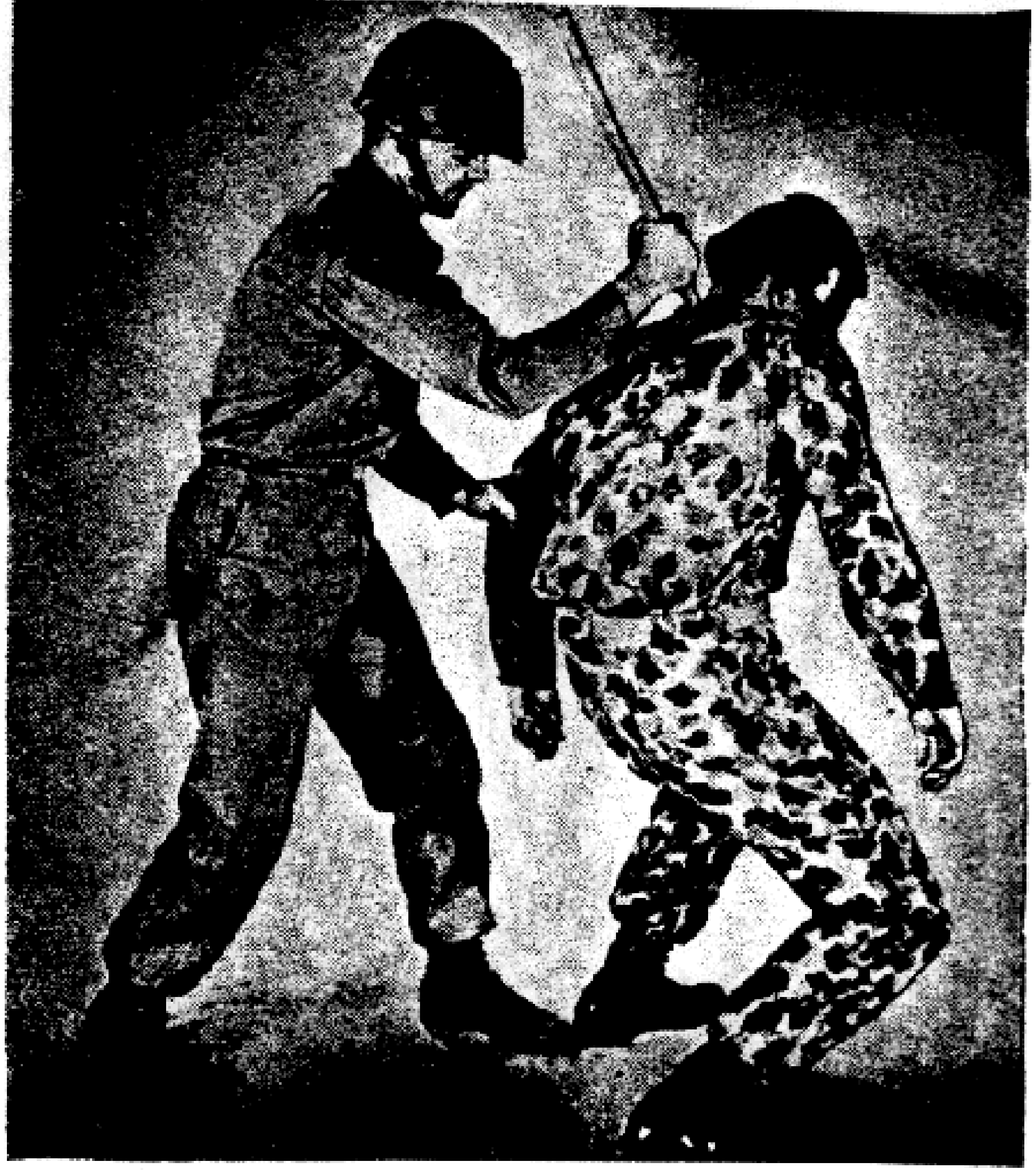


Figure 28.—Attack from the rear using club.

U. S. ARMY HAND-TO-HAND COMBAT

DEPARTMENT OF THE ARMY FIELD MANUAL

FIELD MANUAL No. 21-150
DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C.,

HAND-TO-HAND COMBAT

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CHAPTER 1

INTRODUCTION

1. Purpose and Scope

This manual is written to teach you hand-to-hand combat. It describes the various blows, holds, footwork, armwork, and other maneuvers used to disable or kill an enemy in hand-to-hand fighting. It also explains how to use all available objects as weapons. Hand-to-hand combat stresses simple, aggressive tactics. You can subdue an opponent only through offensive measures.

2. Necessity for Training

The average soldier, if trained only in the use of his basic weapon, loses his effectiveness if his weapon fails to fire or if he should lose or break it. With a knowledge of hand-to-hand combat and the confidence and aggressiveness to fight hand-to-hand, the soldier is able to attack and dispose of his opponent. Training in hand-to-hand combat is also useful for night patrols and other occasions when silence is required. This type fighting is taught to soldiers in rear areas as well as those in front lines because of the threat of infiltration, airborne attacks, and guerilla warfare.

CHAPTER 2

FUNDAMENTALS OF HAND-TO-HAND COMBAT

3. General

Five fundamentals are used as a guide in learning hand-to-hand combat. These fundamentals are making full use of any available weapon; attacking aggressively by using your maximum strength against your enemy's weakest point; maintaining your balance and destroying your opponent's; using your opponent's momentum to advantage; and learning each phase of all the movements precisely and accurately before attaining speed through constant practice.

4. Using Available Weapons

a. When fighting hand-to-hand, your life is always at stake. The use of any object as a weapon, therefore, is necessary to help subdue your enemy. You can make your opponent duck or turn aside by throwing sand or dirt in his face or by striking at him with an entrenching tool, a steel helmet, or a web belt. When no object is available, just the pretense of throwing something may cause an enemy to flinch and cover up. When he does this, you must take advantage of his distraction to attack aggressively with but one purpose in mind—TO KILL.

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b. If no objects are available to use as a weapon, you must make full use of your natural weapons. These are—

(1) *The knife edge of your hand.* Extend your fingers rigidly so the little finger edge of your hand is as hard as possible (fig. 1). Keep your thumb alongside your forefinger.

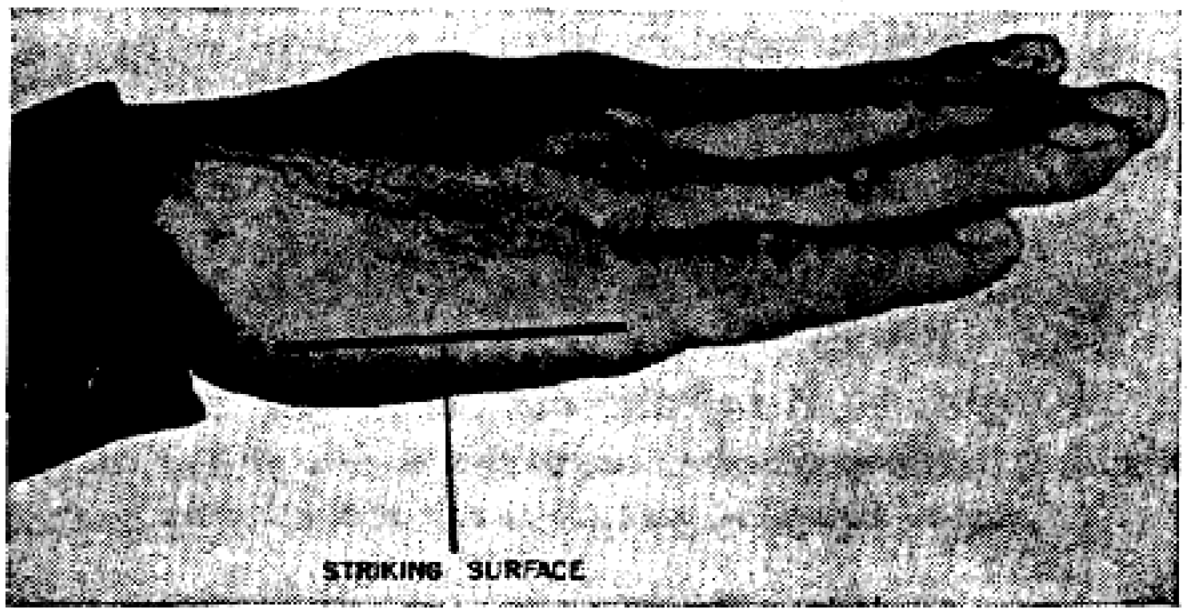

Figure 1. With the knife edge of your hand, you can strike many killing and disabling blows.

(2) *The fingers folded at the second knuckles.* The average fist covers an area of about eight square inches. The fingers folded at the second knuckles gives a striking surface of about two square inches, producing a sharper, more penetrating blow. Keep your thumb tightly against the forefinger to stiffen your hand and keep your wrist straight (fig. 2).

(3) *The protruding second knuckle of your middle finger.* Fold the middle finger at the second knuckle and wedge the second knuckles of your two adjacent fingers into its sides. Keep the end of the thumb over the fingernail of your middle finger and keep your wrist straight (fig. 3).

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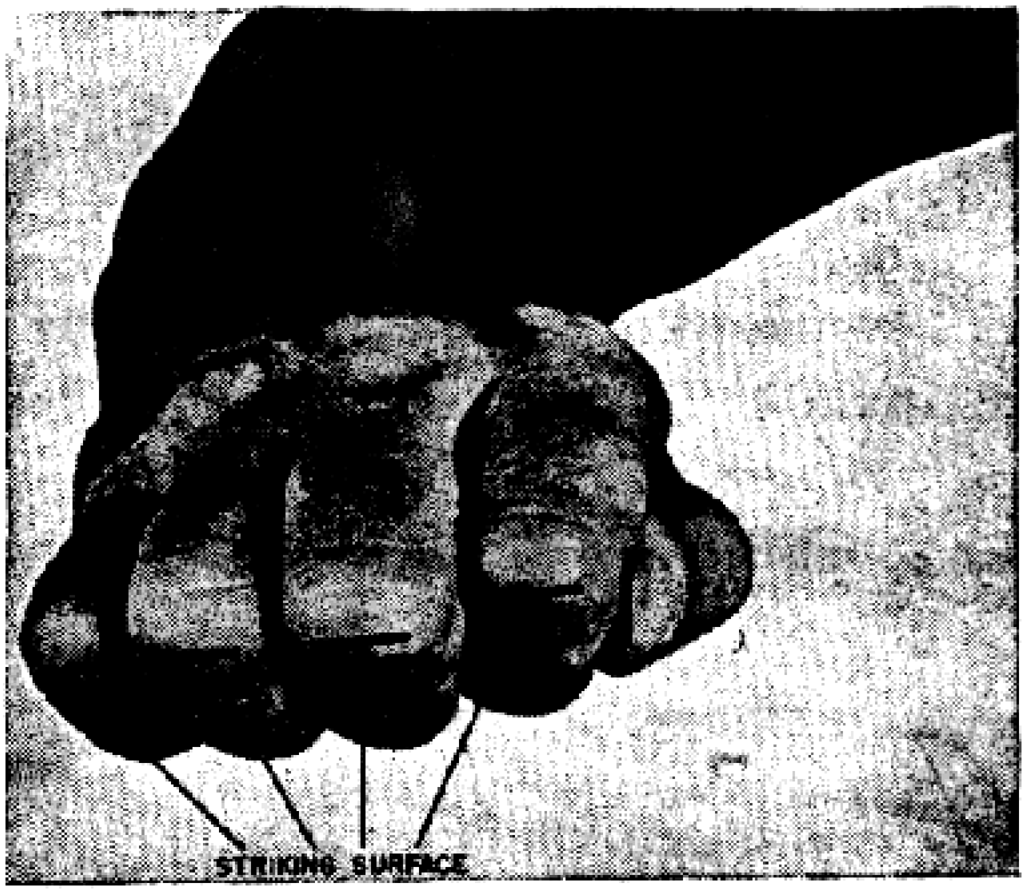

Figure 2. Blows delivered with the fingers folded at the second knuckles produce sharp penetration.

(4) *The heel of your hand.* Fold your fingers at the second knuckles and force the back of your hand toward the wrist to make the heel of your hand as solid as possible (fig. 4). You can deliver a more damaging blow with the heel of your hand than with your fist.

(5) *The little finger edge of your fist.* Form a fist. When using the little finger edge of your fist as a weapon, strike blows in the same motion as when using an ice pick (fig. 5).

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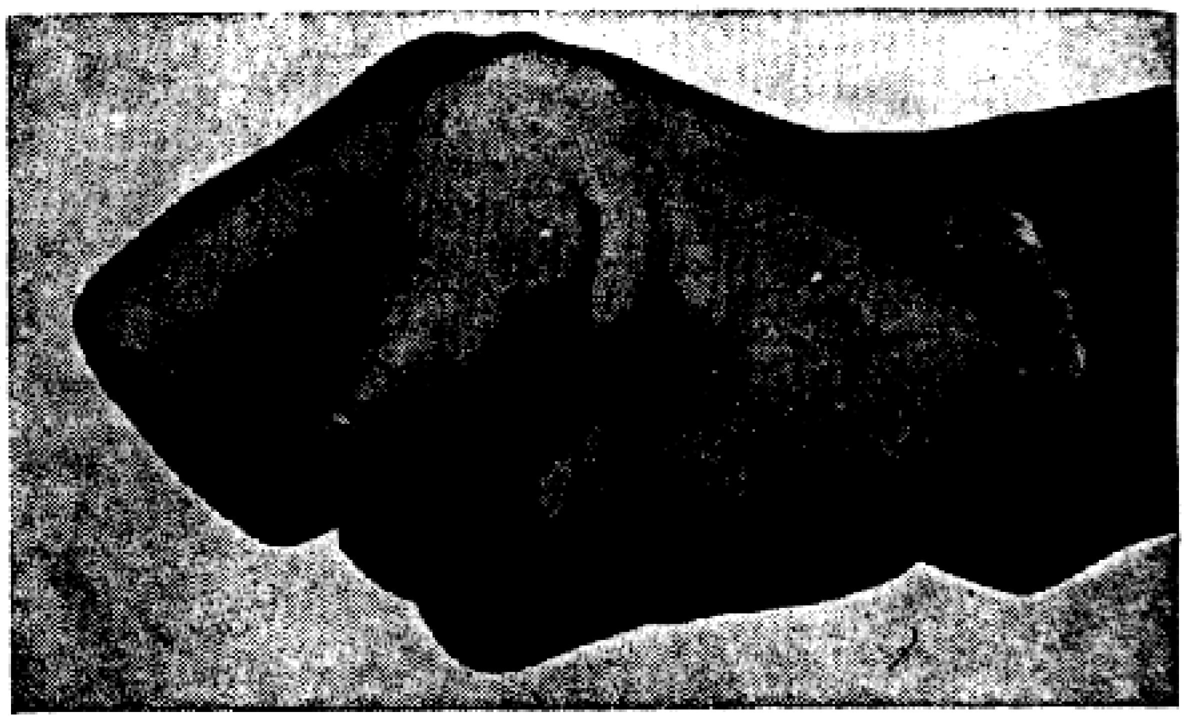

Figure 3. Dangerous blows can be delivered to vulnerable points with the protruding second knuckle of the middle finger.

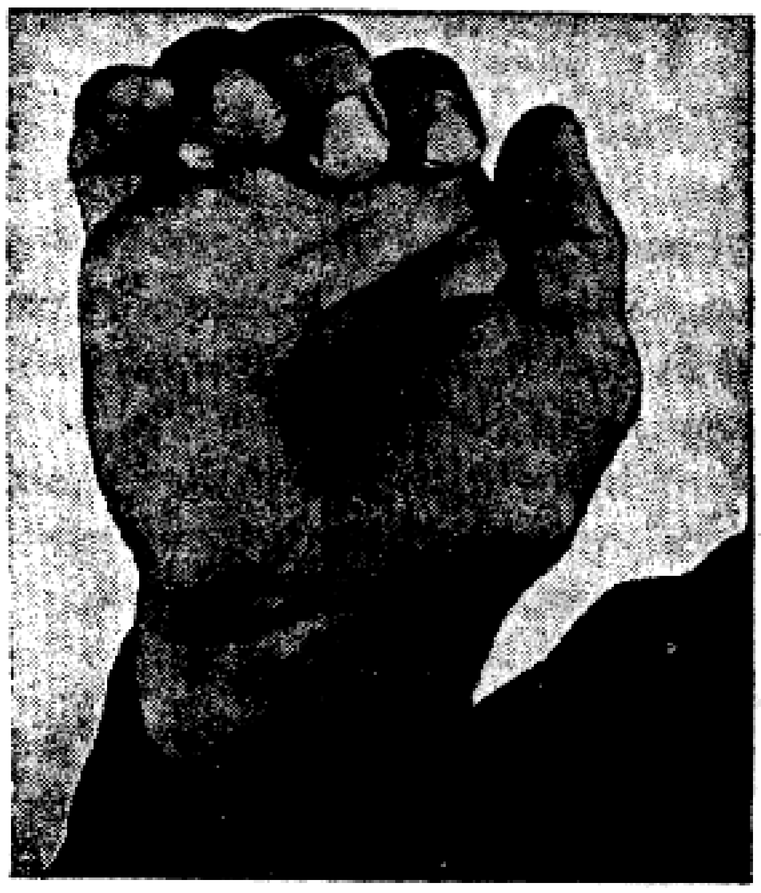

Figure 4. The heel of the hand is particularly effective when attacking parts of the face.

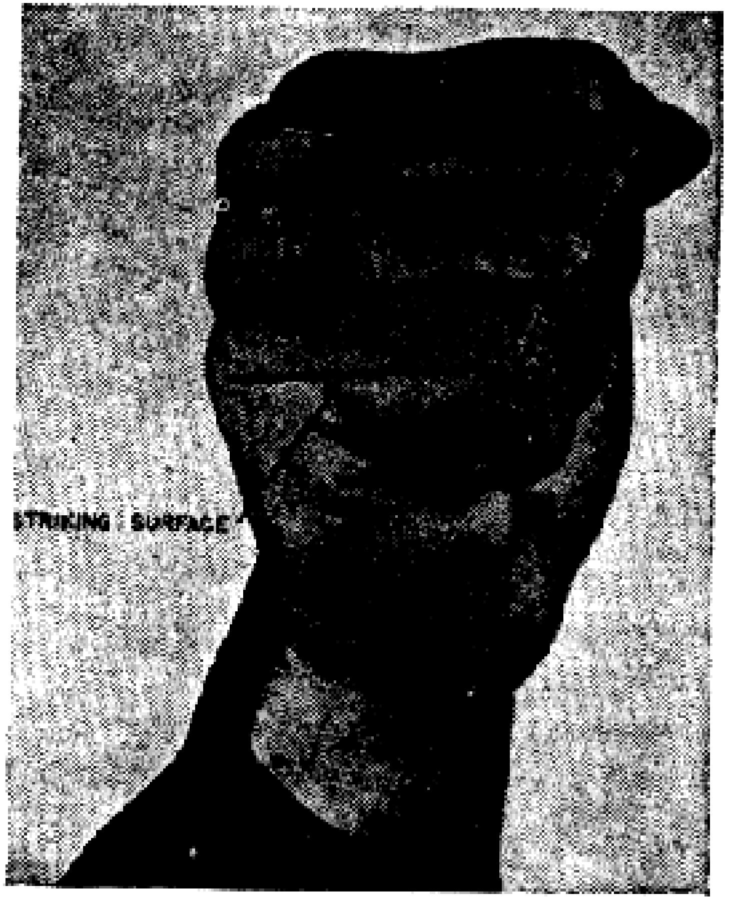

Figure 5. Powerful blows with the little finger edge of the fist can easily kill an opponent.

(6) *Your boot.* For most kicks, use the outside or inside edge of your boot rather than the toe. This provides a much larger striking surface with which to attack small, exposed bony areas (fig. 6).

(7) In addition to the natural weapons already mentioned, you can use your elbows, knees, head, shoulders, and teeth to disable an opponent.

5. Maximum Strength Against Weakest Point

Using maximum strength against your enemy's weakest point is an axiom of war that equally applies to combat between two individuals. In every situation, some extremely vulnerable area of your opponent is open for attack. By aggressively assaulting these vulnerable areas, using the maximum strength offered by your position, you can gain a quick victory. Attacking rather than defending is the keynote because only through the use of offensive tactics are you able to dispose of your enemy.

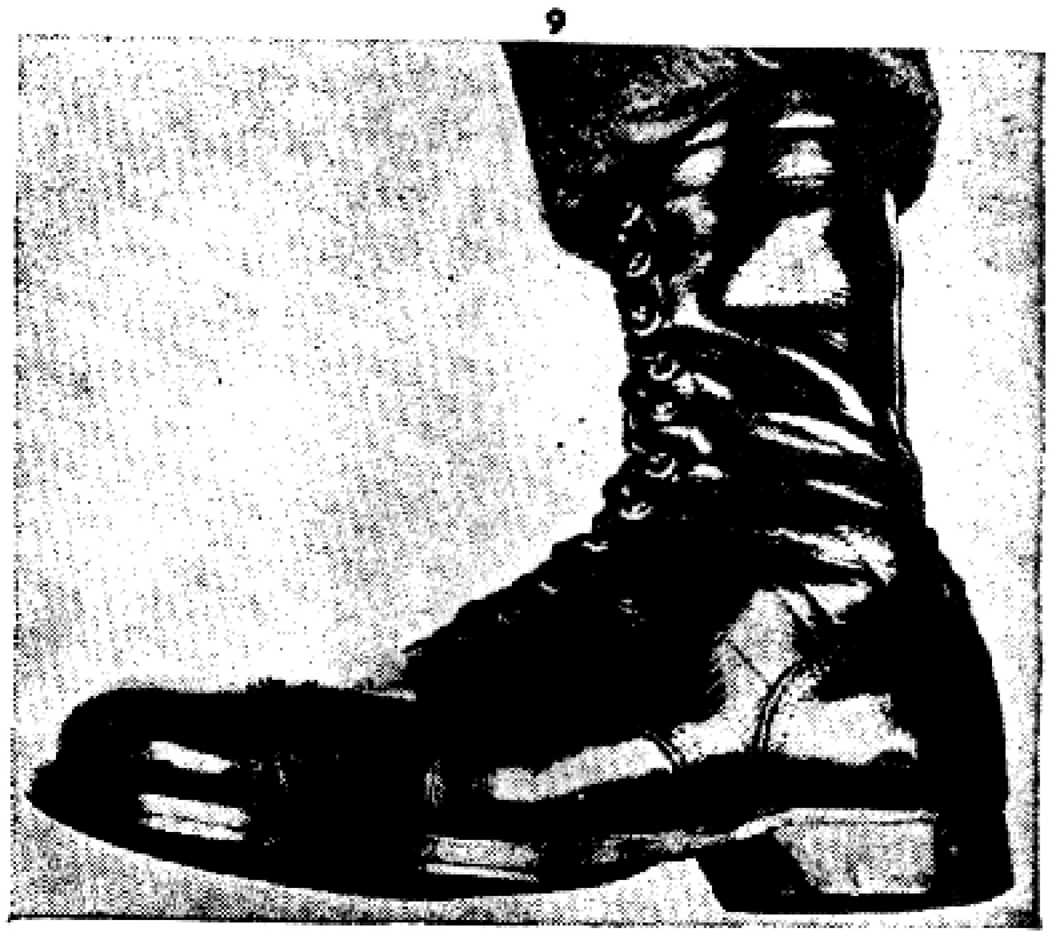

Figure 6. The inside or outside edge of the boot is more effective than the toe, which may slip off small areas.

6. Balance

a. Keeping your own balance, while causing your opponent to lose his, is an important essential of successful fighting. Assume the guard position when engaging your opponent (fig. 7). This position is similar to a boxer's crouch and enables you to react rapidly and move in any direction. Spread your feet about shoulder's width apart, with your left heel generally on line with your right toe. If you are left handed, reverse this position and bring your left foot behind your right foot. Bend your body forward at the waist and at the knees slightly. Hold the hands at face level and slightly in front of it. Extend and join your fingers, with the thumbs along the forefingers and the palms facing inward. Face your opponent squarely. The guard position offers you the best balanced position you can obtain before closing with your opponent. You will improve your sense of balance and learn to destroy your opponent's balance after closing with him by practicing the maneuvers presented in this manual.

b. When fighting, keep your feet spread laterally to maintain balance. Destroy your opponent's mental balance by growling and yelling as you strike at him.

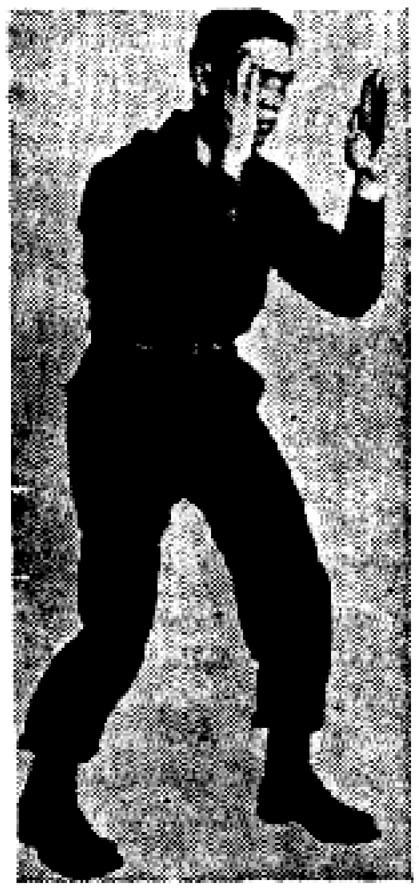

Figure 7. The guard position offers good balance and good all-around protection.

7. Momentum

Using your opponent's momentum to your own advantage is another fundamental. Always assume that your opponent is stronger than you and never oppose him directly in a test of strength. Instead, utilize his momentum and strength to overcome him. Examples of using your opponent's momentum are tripping him, side stepping as he rushes you, or ducking his blow.

8. Accuracy and Speed

You will have little time to stop and think when engaging in hand-to-hand combat. Therefore, your actions must be automatic. At the beginning, learn each phase of each movement separately and accurately, putting the stress on precision alone. As you progress, work for speed through constant practice. Speed is essential to the successful employment of most of the maneuvers outlined in this manual.

CHAPTER 3

VULNERABLE POINTS

Section I. INTRODUCTION

9. General

a. Vulnerable points are areas of the body that are particularly susceptible to blows or pressure. Knowledge of these points and how to attack them, plus aggressiveness and confidence, will enable you to attack and quickly disable or kill the enemy you meet in hand-to-hand combat.

b. When you are attacking an opponent, your first reaction is probably to strike him on the jaw with your closed fist. This is one of the poorest ways to fight. A better attack is to strike your opponent across the bridge of his nose with the knife edge of your hand. This type blow could easily break the thin bone in his nose, causing extreme pain and temporary blindness. A severe blow could drive bone splinters into his brain and cause instant death. These actions must be performed *without hesitation* and *with aggressiveness.*

10. Body Regions

The body is divided into three regions: The head and neck, the trunk, and the limbs. Here is a list of the major vulnerable points of each region—

Head and neck	*Trunk*	*Limbs*
a. Eyes.	*a.* Groin	*a.* Instep
b. Nose	*b.* Solar plexus	*b.* Ankle
c. Adam's apple	*c.* Spine	*c.* Knee
d. Temple	*d.* Kidney	*d.* Shoulder
e. Side of neck	*e.* Collar bone	*e.* Elbow
f. Nape	*f.* Floating ribs	*f.* Wrist
g. Upper lip	*g.* Stomach	*g.* Fingers
h. Ears	*h.* Armpit	
i. Base of throat		
j. Chin		

11. Caution

Only a small amount of pressure or a light blow is needed to injure or kill a man when attacking some of the vulnerable points. It is important, therefore, to strike very light blows in training when learning how to attack these points. When thoroughly trained, you may add a little more force to your blows; but still remember the vulnerability of the area being attacked in order not to injure your training partner.

Section II. HEAD AND NECK

12. Eyes

There are various ways to blind an opponent. One is to drive your index and middle fingers, formed into a V, into your opponent's eyes (fig. 8). Keep your fingers stiff and your wrist firm. You can also use the second knuckles of two adjacent fingers in a sharp thrust at the eyes. The eyes can be gouged out by using your thumbs or fingers.

13. Nose

When attacking the nose, strike a forceful blow with the knife edge of your hand across the bridge (fig 9). This blow can easily break the thin bone,

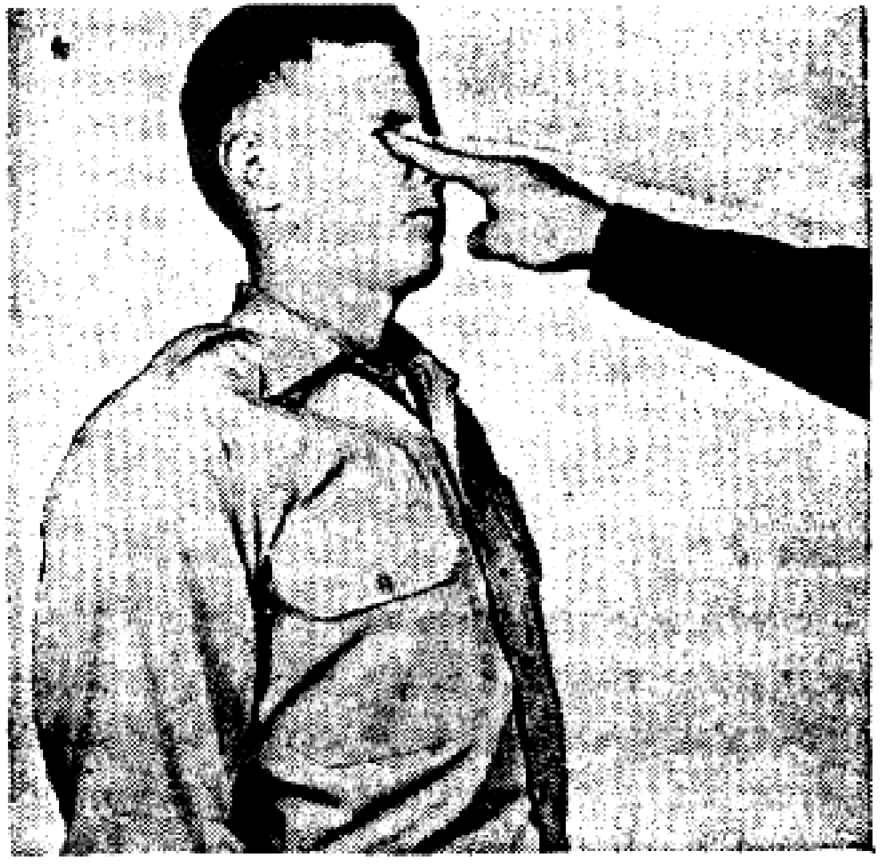

Figure 8. The fingertips driven forcefully into the eyes can easily blind an opponent.

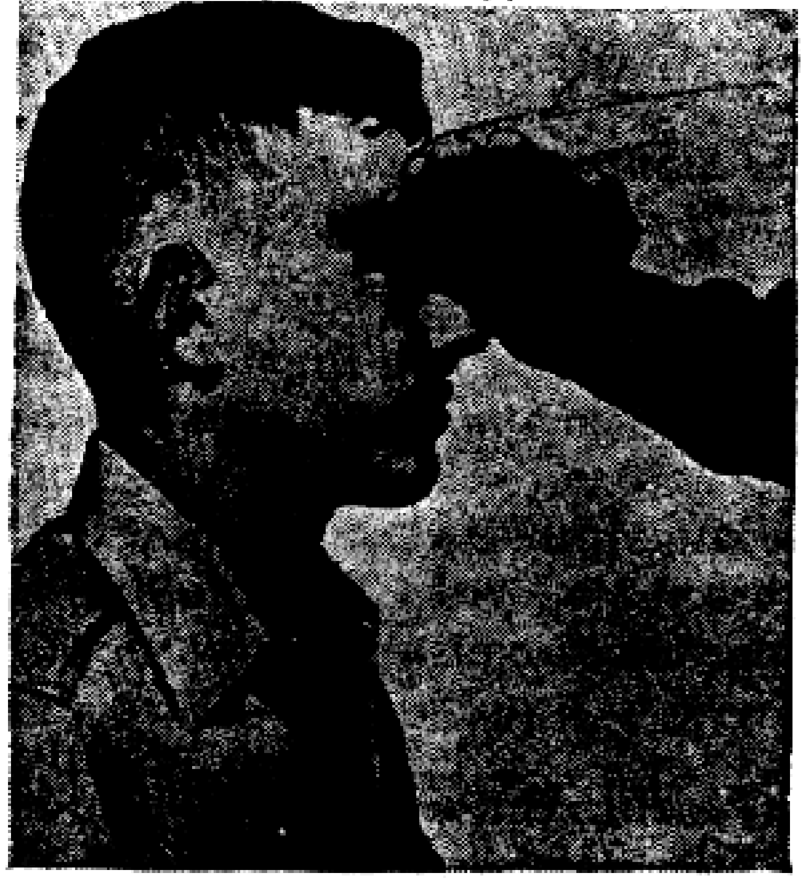

Figure 9. A forceful blow to the bridge of the nose will knock an opponent out of action.

causing your opponent extreme pain and temporary blindness. A very sharp blow could drive bone splinters into your opponent's brain and kill him instantly. You can also use the outside edge of your closed fist. When fighting at close quarters, attack the nose by hitting the bottom of it an upward blow with the heel of your hand.

14. Adam's Apple

Attack the Adam's apple with the knife edge of your hand (fig. 10). A severe blow can result in death by severing the windpipe. A lesser blow is painful and causes your opponent to gag. The Adam's apple is also vulnerable to attack with the fist, toe, or knee, depending upon your opponent's position. Squeezing it or pulling it outward with the fingers and thumb is another method you can use.

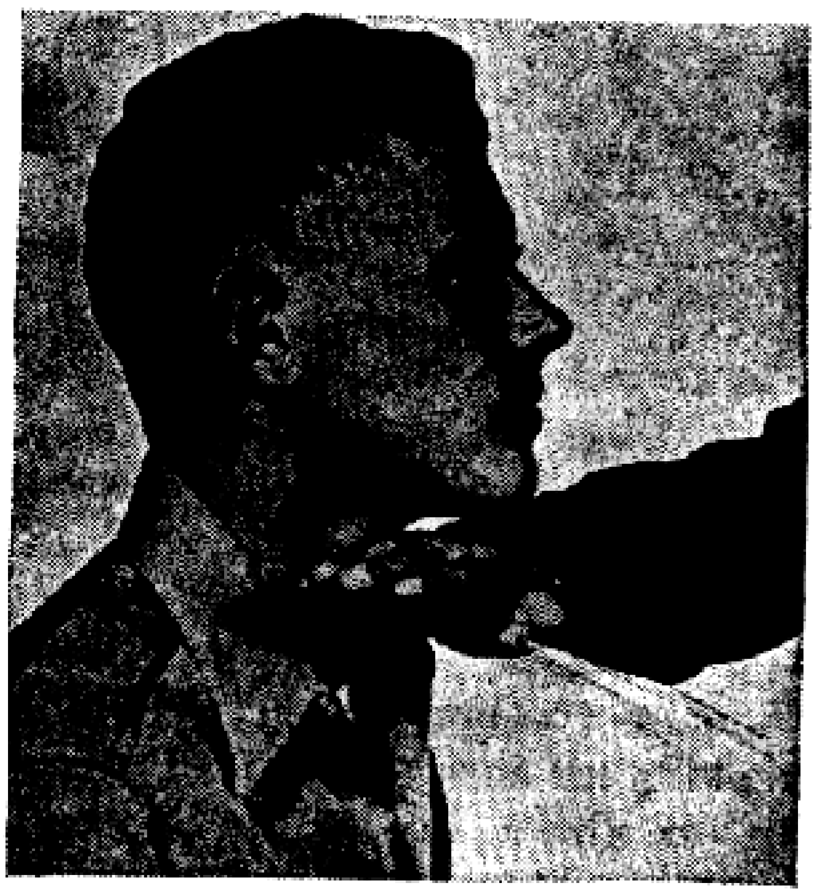

Figure 10. A severe blow to the Adam's apple with the knife edge of the hand can kill.

15. Temple

A blow to the temple can easily kill or cause a concussion. The bone structure at this spot is weak and an artery and a large nerve lie close to the skin. Attack the temple with the knife edge of your hand or with the outside edge of your closed fist (fig. 11). A jab with the point of your elbow can also be used. If you succeed in knocking your opponent down, kick his temple with your toe.

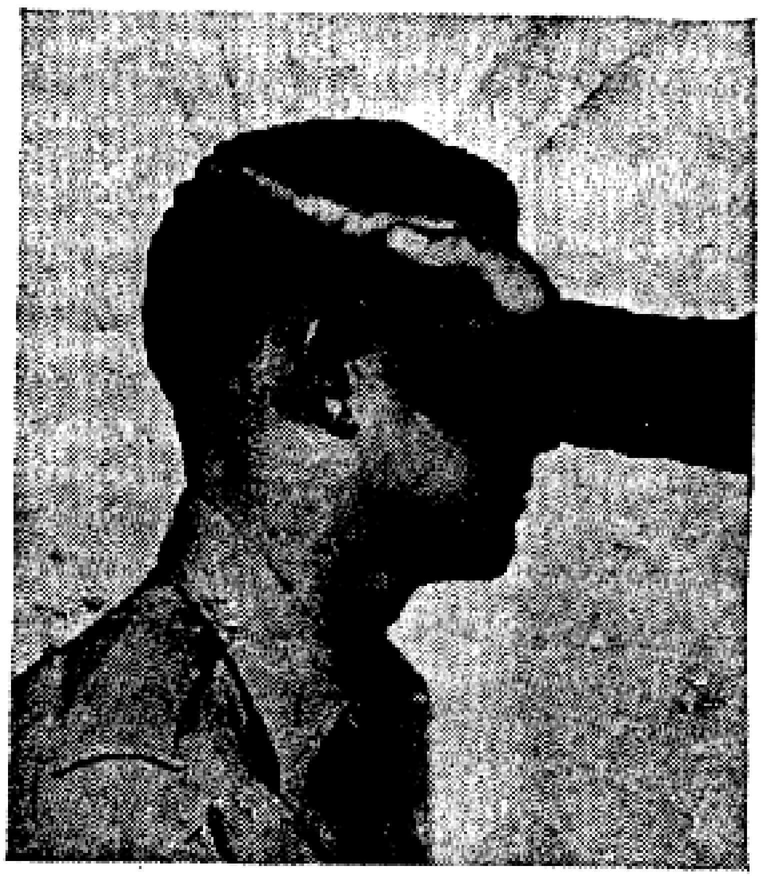

Figure 11. The temple is a weak part of the body. A forceful blow here will usually kill an enemy.

16. Nape

A blow with the knife edge of your hand to your opponent's nape ("rabbit punch") could easily kill him by breaking his neck (fig. 12). The outside edge of your fist can also be used. Use this blow if your opponent charges low and his hands are not guarding the upper regions of his body. If you succeed in

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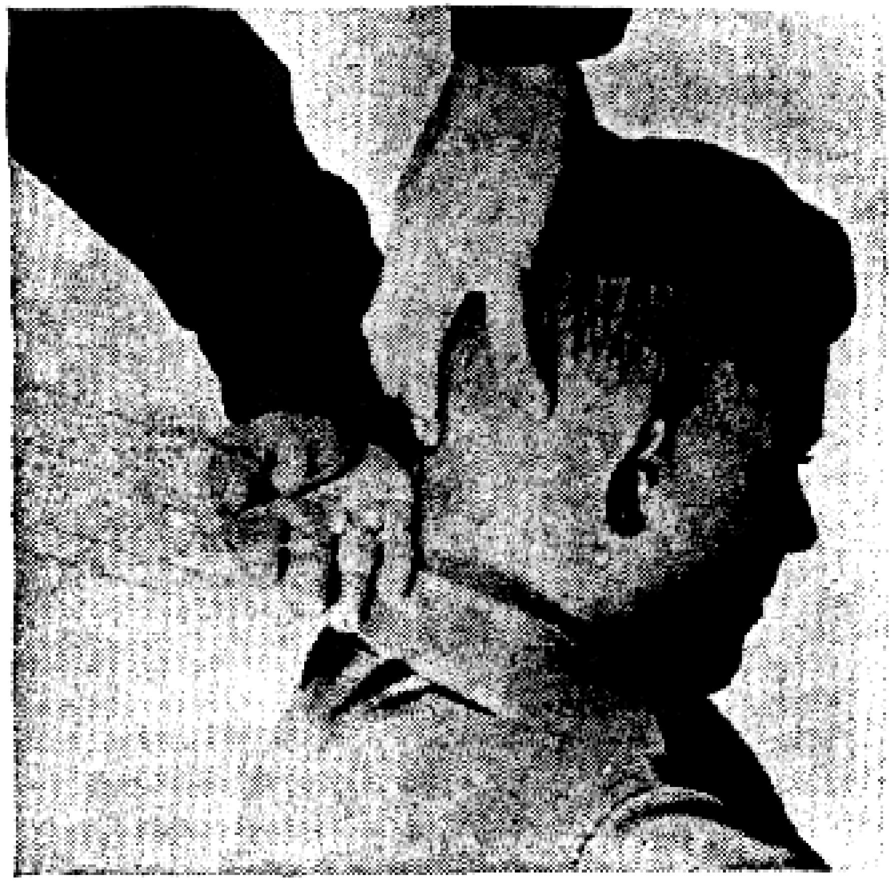

Figure 12. The "rabbit punch" (blow to nape).

knocking your opponent down, kick his nape with your toe, stomp it with your heel, or strike it with the knife edge of your hand.

17. Side of Neck

One way to knock your opponent unconscious is to deliver a sharp blow with the knife edge of your hand to the side of the neck, below and slightly to the front of the ear (fig. 13). You can deliver it in two ways: A backhand delivery with the palm down or a forward slash with the palm up. This type blow causes unconsciousness by shocking the jugular vein, the carotid artery, and the vagus nerve. It is not particularly dangerous.

18. Upper Lip

A vulnerable part of the face is the upper lip, just below the nose, where the nose cartilage joins the bone. The nerves here are close to the skin. This area can be attacked by delivering a sharp blow with the knife edge of your hand at a slightly upward angle (fig. 14). A very sharp blow can cause unconsciousness. A lesser blow causes extreme pain. A jab with the second knuckles of your fingers can also be used.

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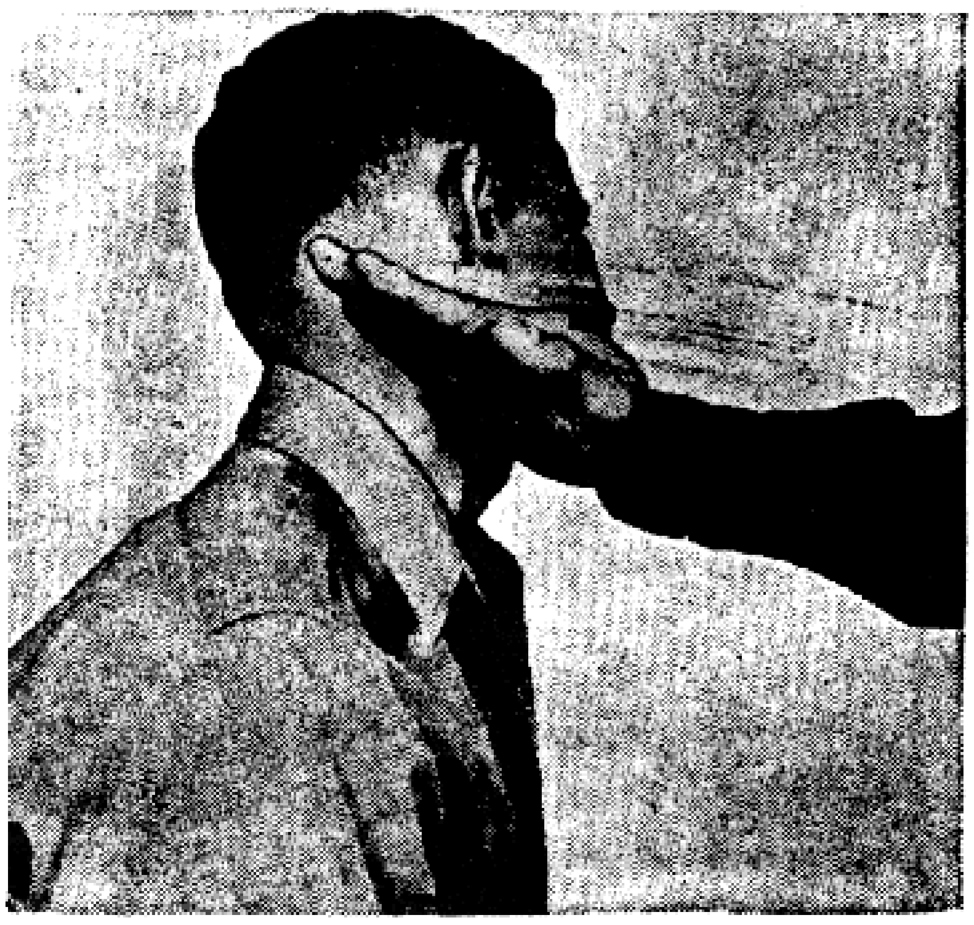

Figure 13. A blow to the side of the neck will not kill an enemy, but if delivered forcefully, it can cause unconsciousness.

19. Ears

Cup your hands and clap them simultaneously over your opponent's ears (fig. 15). This is a dangerous blow and may burst his ear drums, cause nerve shock, or result in possible internal bleeding. A sharp enough blow can cause a brain concussion and death.

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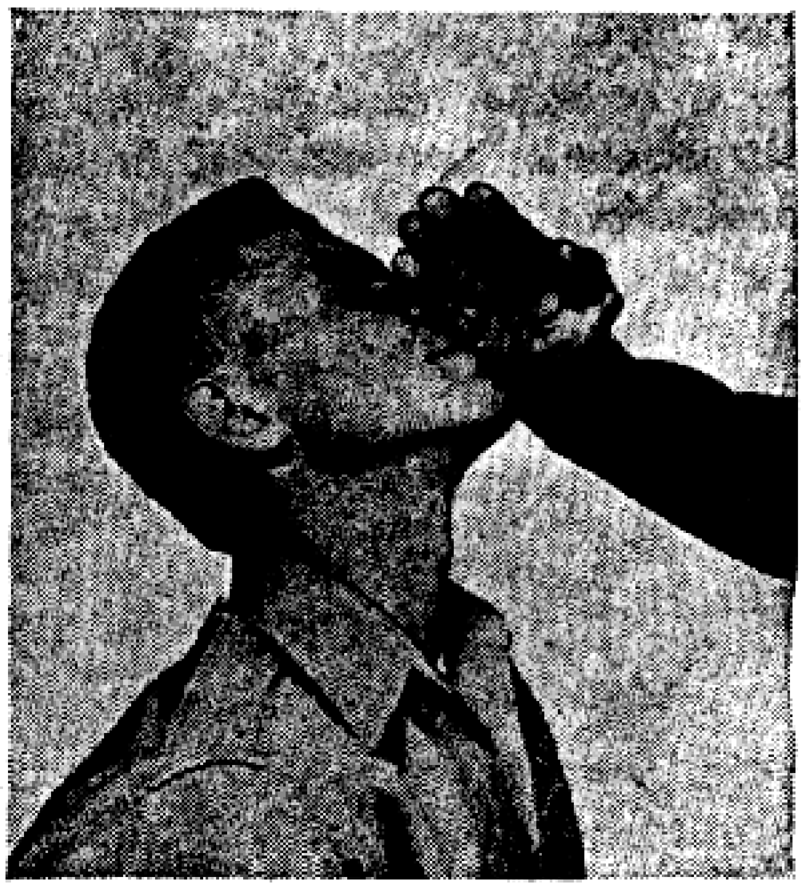

Figure 14. The upper lip is a good place to attack when fighting close-in.

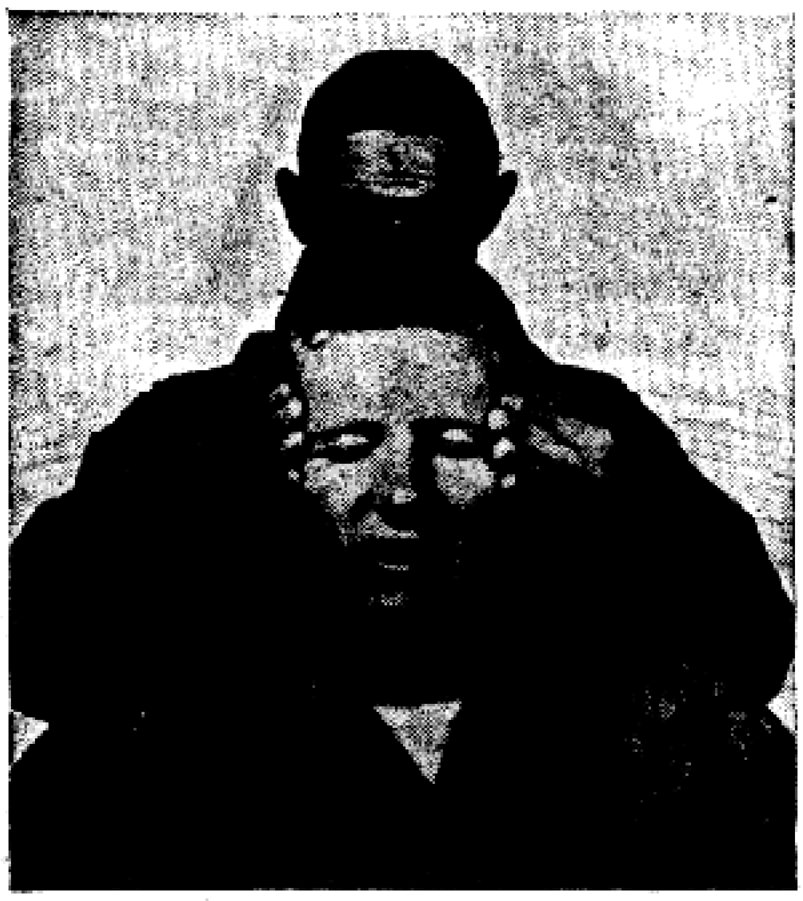

Figure 15. Clapping cupped hands over an enemy's ears can kill.

20. Base of Throat

One way to break an opponent's hold on you is to quickly thrust one or two extended fingers into the small indentation at the base of his throat (fig. 16). The blow is painful and causes him to gag and cough. Severe injury could result if the thin layer of skin at this point is pierced.

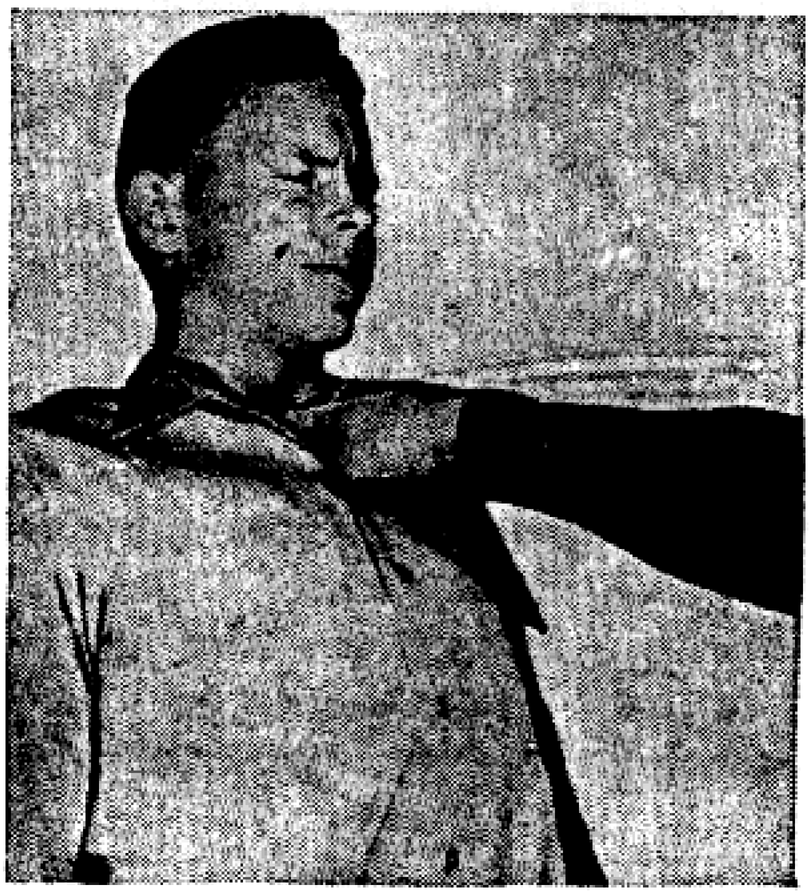

Figure 16. Jabbing a finger or fingers into the base of an opponent's throat causes him to loosen a hold.

21. Chin

An effective blow can be delivered to your opponent's chin with the heel of your hand, which is better than a closed fist (fig. 17). You may break a bone in your hand by using your fist.

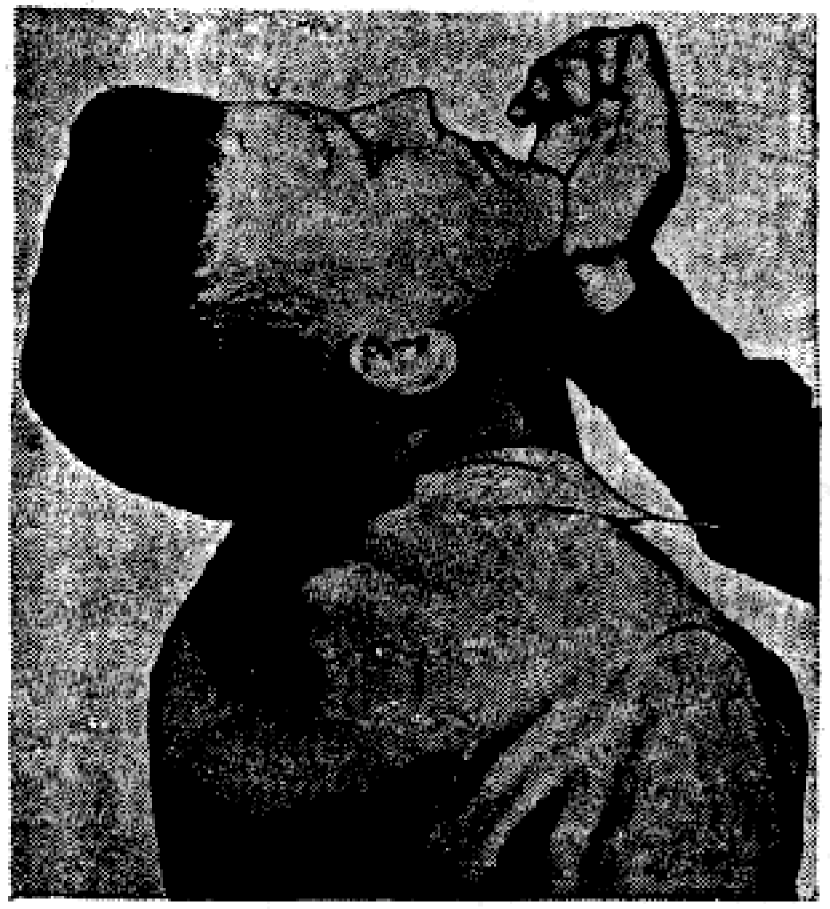

Figure 17. Striking an opponent on the chin with the heel of the hand is better than striking him with a fist.

Section III. TRUNK

22. Groin

When closing with an opponent, keep in mind that one of the best points to attack is the groin. Attack it, by kicking up forcefully with your knee (knee-lift) (fig. 18). You can also use your closed fist, the knife edge of your hand, grasping fingers, a toe kick, or a heel stomp.

23. Solar Plexus

The solar plexus is at the bottom of the rib cage, just beneath the breast bone. To attack this area, thrust sharply with the second knuckle of the protruding middle finger (fig. 19). This method permits sharp penetration and is, therefore, more effective than striking this small target with the fist

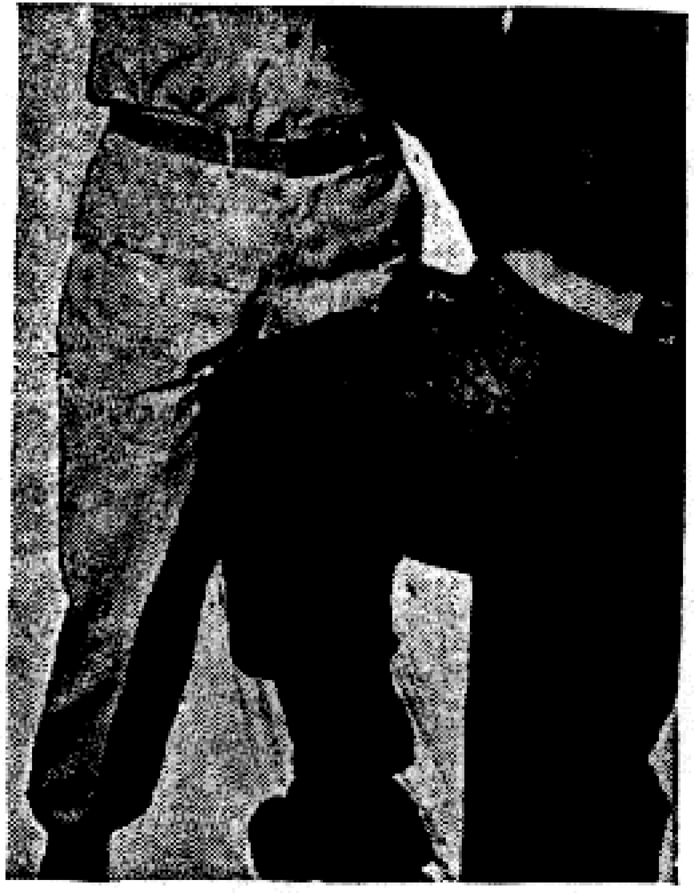

Figure 18. Attacking the groin is one of the most effective methods of subduing an opponent.

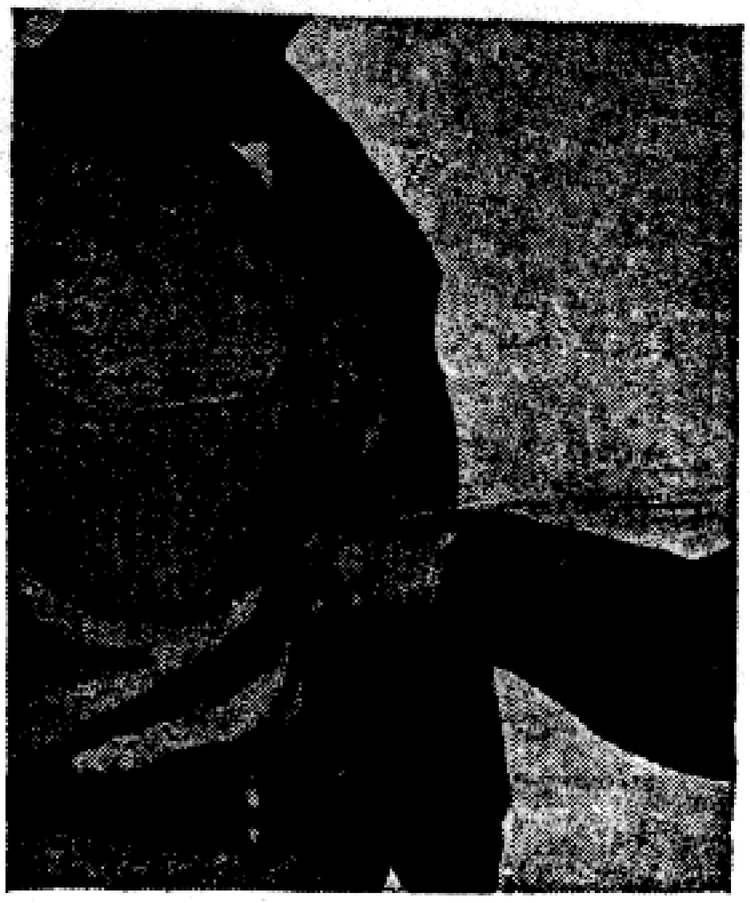

Figure 19. A blow to the solar plexus with the protruding knuckle of the middle finger permits sharp penetration.

or the knife edge of your hand. Any sharp blow to the solar plexus causes extreme pain and may either bend your opponent forward or drop him to his knees. Death may result from a severe blow.

24. Spine

The spinal column houses the spinal cord and a blow here can cause derangement of the column, resulting in paralysis or death. If you succeed in knocking your opponent down, a blow with your knee, your elbow, the heel of your shoe, or a toe kick can easily kill or seriously injure him (fig. 20). The best place to strike this blow is three or four inches above the belt line where the spine is least protected.

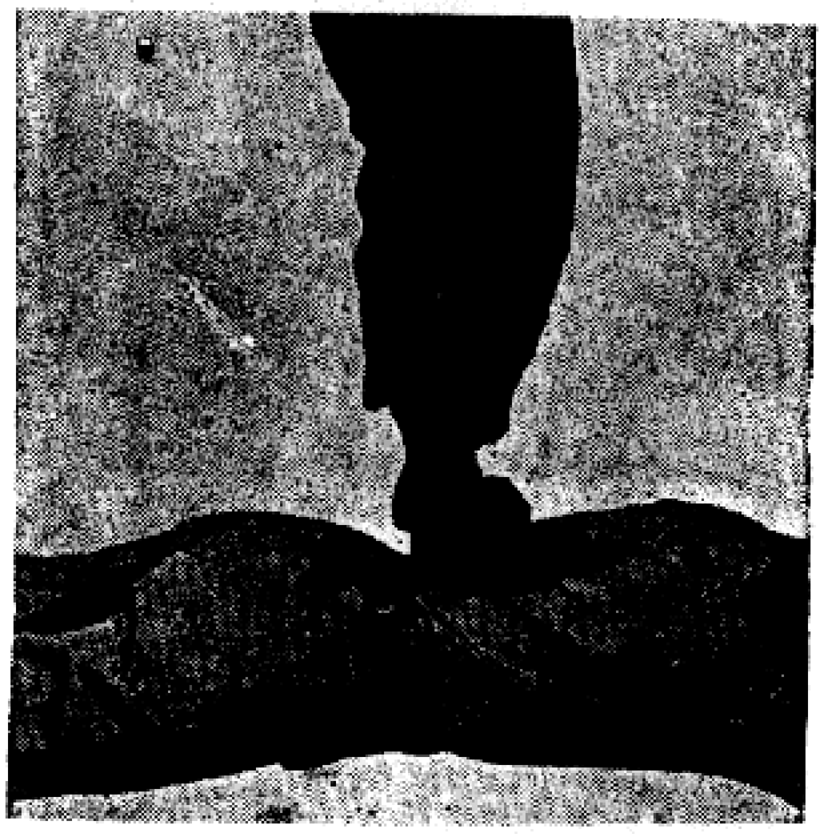

Figure 20. A blow to the spine can easily kill or seriously injure an opponent.

25. Kidney

Certain large nerves, branching from the spine, are very close to the skin surface over the kidneys. A blow here can rupture the kidney and cause severe nervous shock or death unless the victim receives immediate medical attention. To attack this area, use the knife edge of your hand (fig. 21). Other effective blows can be delivered with fingers folded at the second joints, the outside edge of your fist, the knee, or a toe kick.

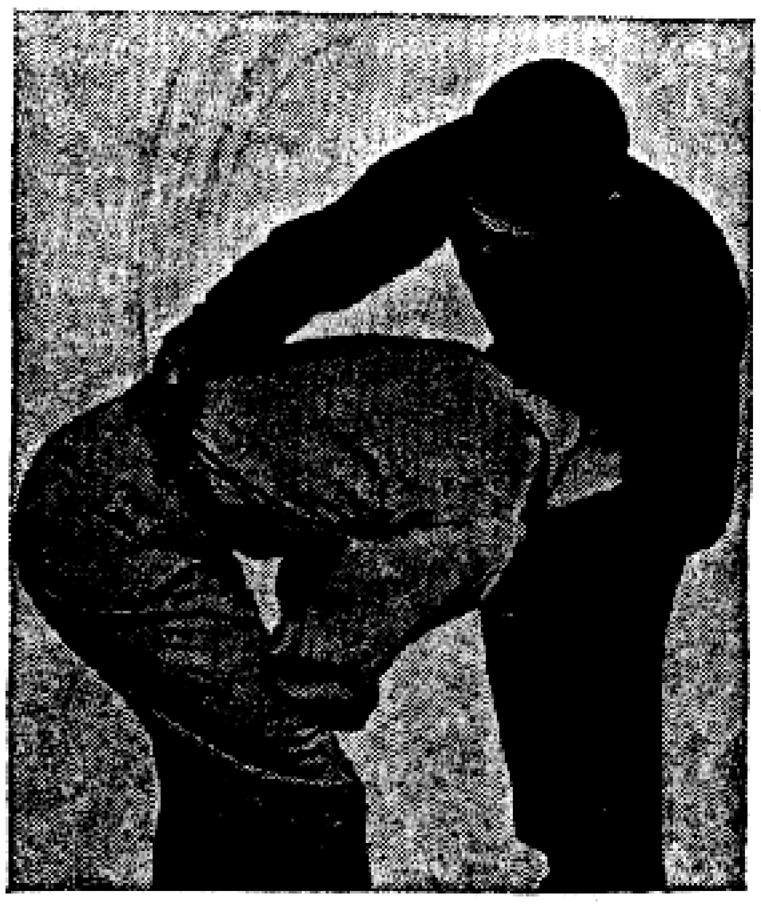

Figure 21. Attacking the kidney.

26. Collar Bone

A forceful blow delivered straight down on the collar bone at the side of the neck with the knife edge of your hand can fracture the bone and cause your opponent to drop to his knees (fig. 22). Another way of attacking this point, and a particularly good way if your opponent is shorter than you, is to drive your elbow down into the collar bone.

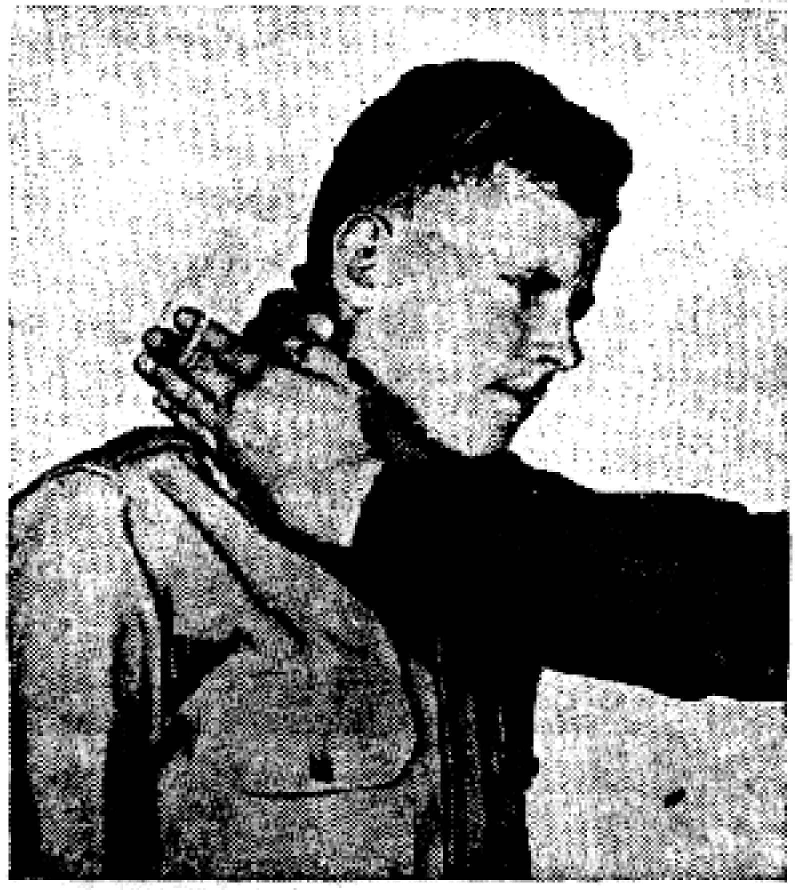

Figure 22. The knife edge of the hand is an effective weapon to use against the collar bone.

27. Floating Ribs

Attack the floating ribs from either the front or rear, but, if possible, strike the blow to your opponent's right side. The liver is located here just below the ribs, and the blow causes terriffic shock to this organ. Attack this area with the knife edge of your hand (fig. 23), the outside edge of your fist, the knuckles folded at the second joints, the heel, the toe, or the knee.

28. Stomach

A blow to your opponent's stomach with your knuckles folded at the second joints causes him to loosen his hold on you (fig. 24). If he bends forward, strike him in the face with your knee or deliver a "rabbit punch" to his nape. The knuckle blow gives sharper penetration than a blow with the elbow or fist. A toe kick or a kneelift can also be used and could cause serious injury.

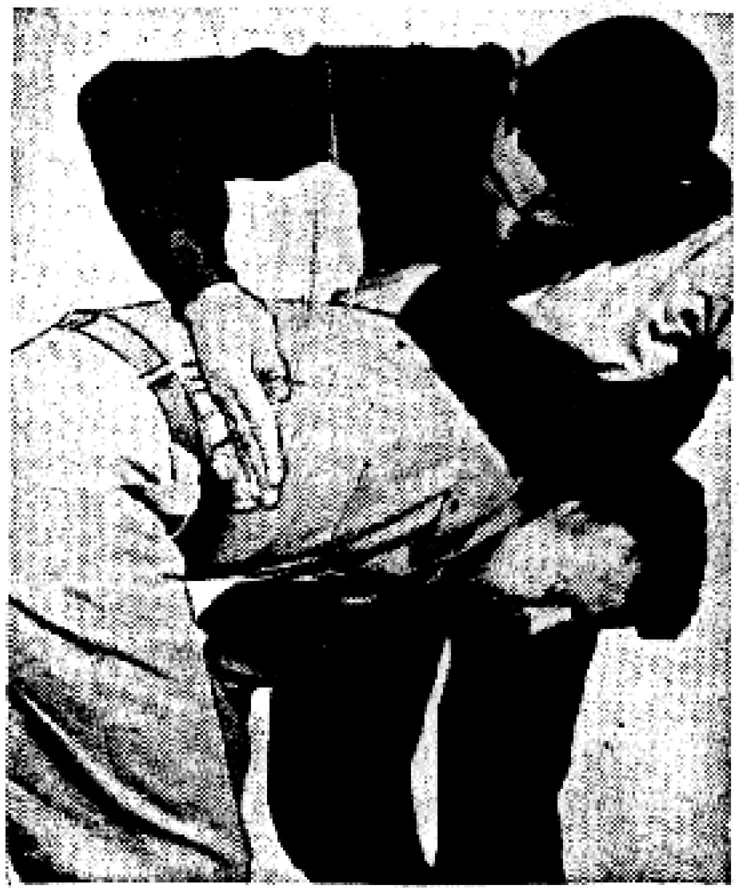

Figure 23. Attacking the floating ribs.

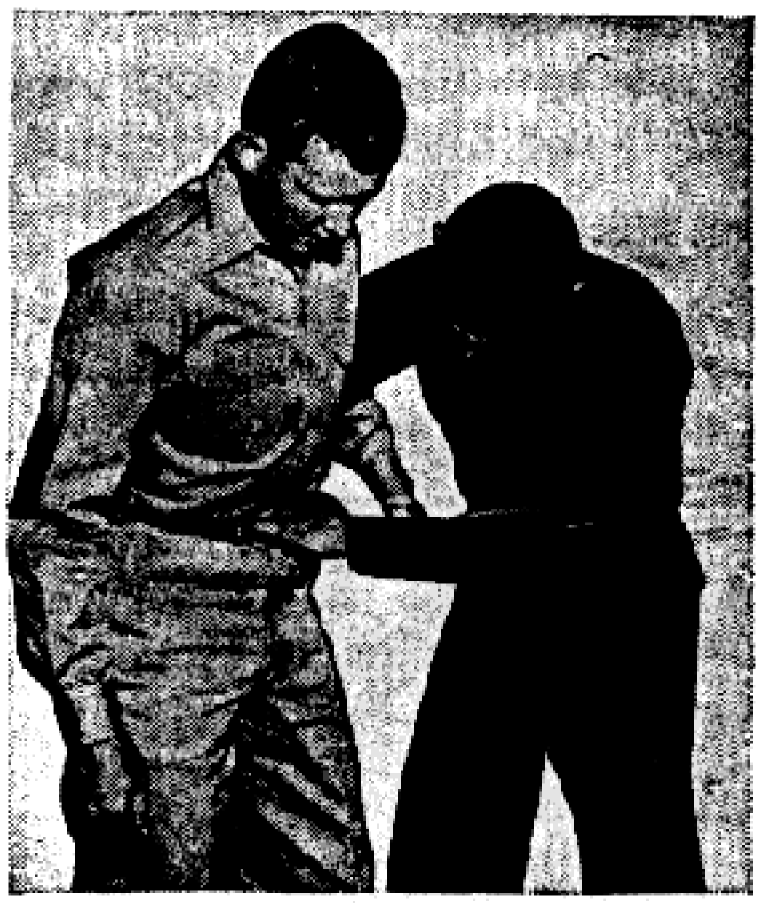

Figure 24. To break a hold, hit an opponent in his stomach with the knuckles folded at the second joints.

29. Armpit

A large nerve is close to the skin in the armpits. A blow to this area causes severe pain and temporary partial paralysis. If you succeed in knocking your opponent down, attack the armpit with a toe kick (fig. 25).

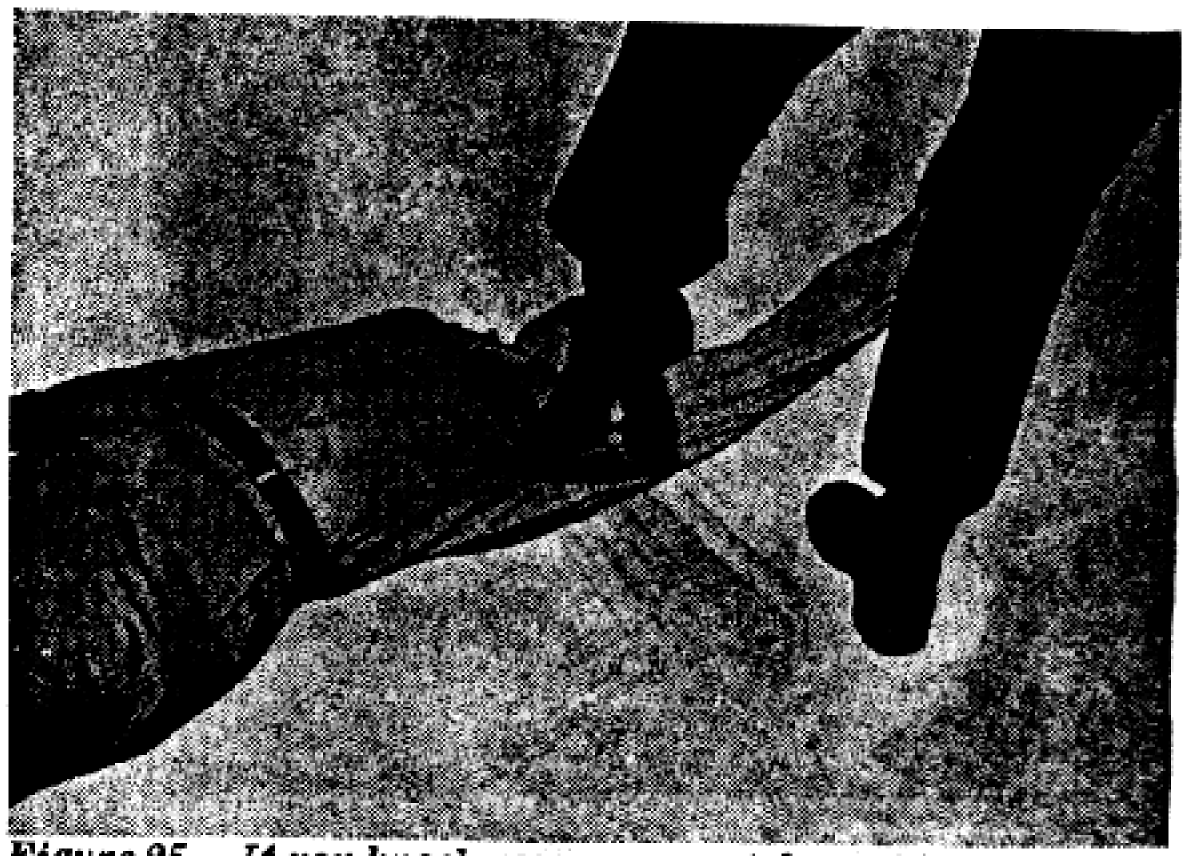

Figure 25. If you knock your opponent down, kick his armpit to cause temporary partial paralysis.

Section IV. LIMBS

30. Instep

The small bones of the instep can easily be broken with a stomp, causing severe pain to your opponent as well as limiting his movement. When facing your opponent, deliver a stomp with the edge of your left boot to his left instep or with the edge of your right boot to his right instep (fig. 26). This type delivery protects your groin area as you turn. Follow the blow to the instep with a blow to the ankle. Kick your opponent sharply on the outside of his ankle with the outside edge of your boot. Do not use a toe kick because it may slip off your opponent's ankle without doing damage.

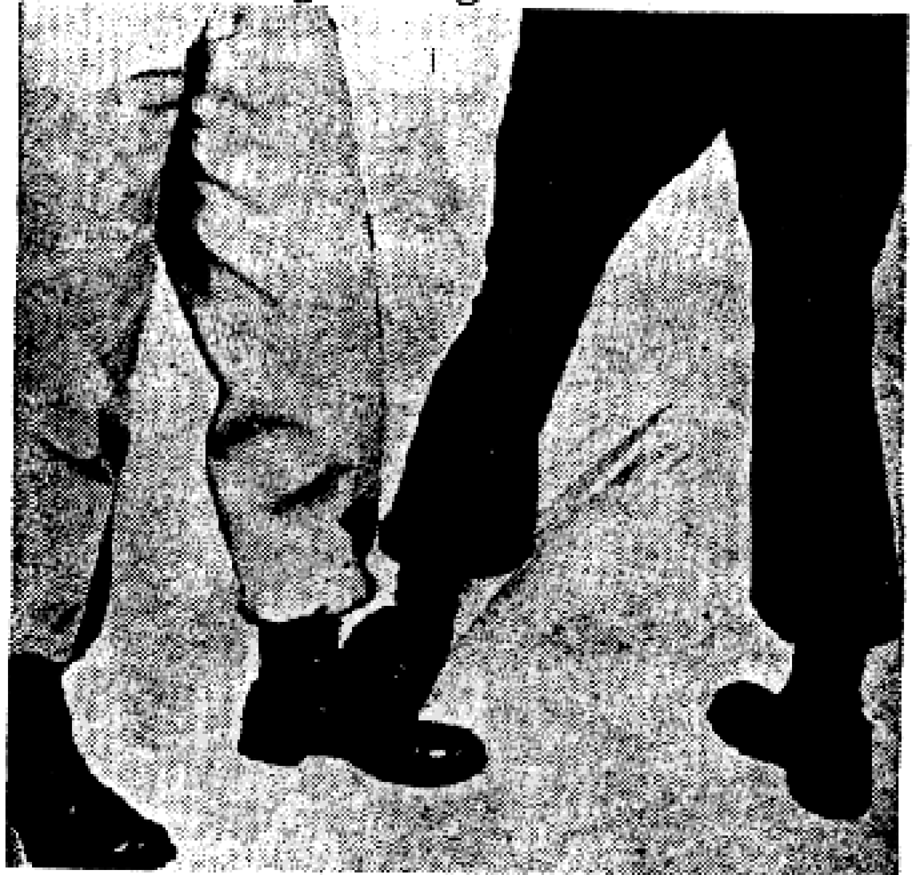

Figure 26. A stomp to an opponent's instep can easily break the bones here.

31. Knee

Kick your opponent's knee or kneecap with the edge of your boot (fig. 27). The blow will tear ligaments and cartilage, causing him extreme pain and affecting his mobility. If you succeed in getting

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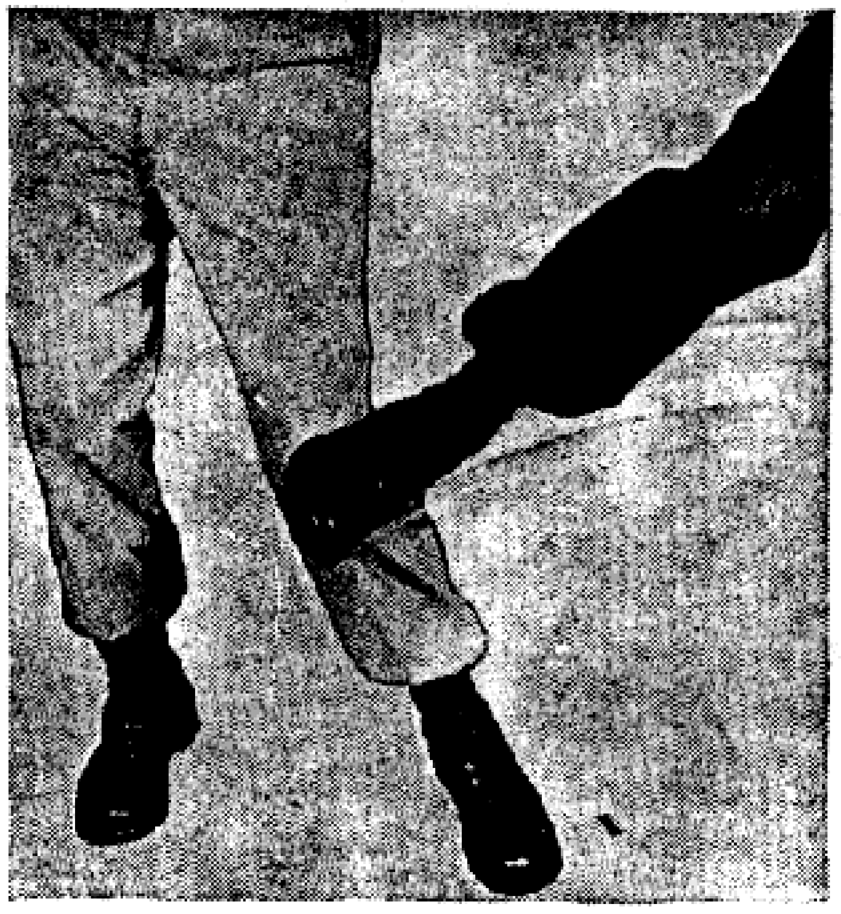

Figure 27. A kick to an opponent's knee will hinder his mobility.

behind your opponent, a sharp toe kick to the back of his knee will penetrate his flesh and injure the nerves.

32. Shoulder

After you knock your opponent down, you can easily dislocate his shoulder by twisting his arm behind his back and dropping on his shoulder with your weight on one knee (kneedrop) (fig. 28). When you are in position to do this, you also can fall on your opponent's spine, causing paralysis or immediate death.

33. Elbow

The elbow joint is a comparatively weak part of the body and a forceful blow can dislocate it. Grasp your opponent's wrist or forearm and pull it behind him, stiffening his whole arm (fig. 29). As you do this, give his elbow a sharp blow with the heel of your hand. The knife edge of your hand or your knee can also be used.

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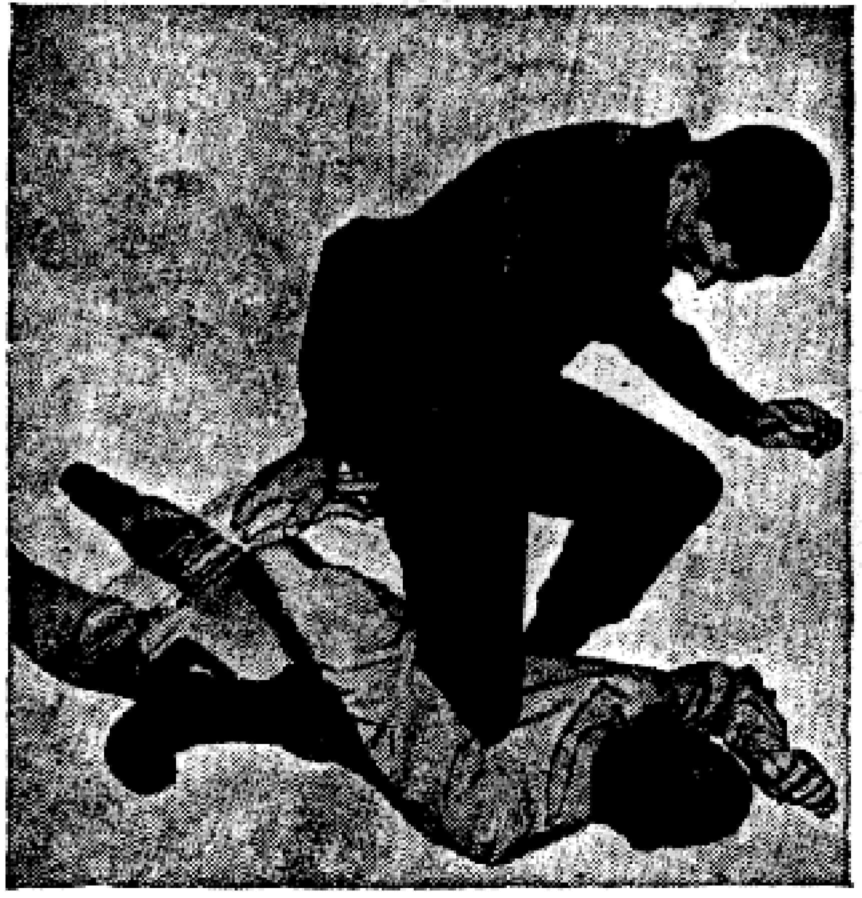

Figure 28. A kneedrop to an opponent's shoulder will dislocate this part of the body and make his arm useless.

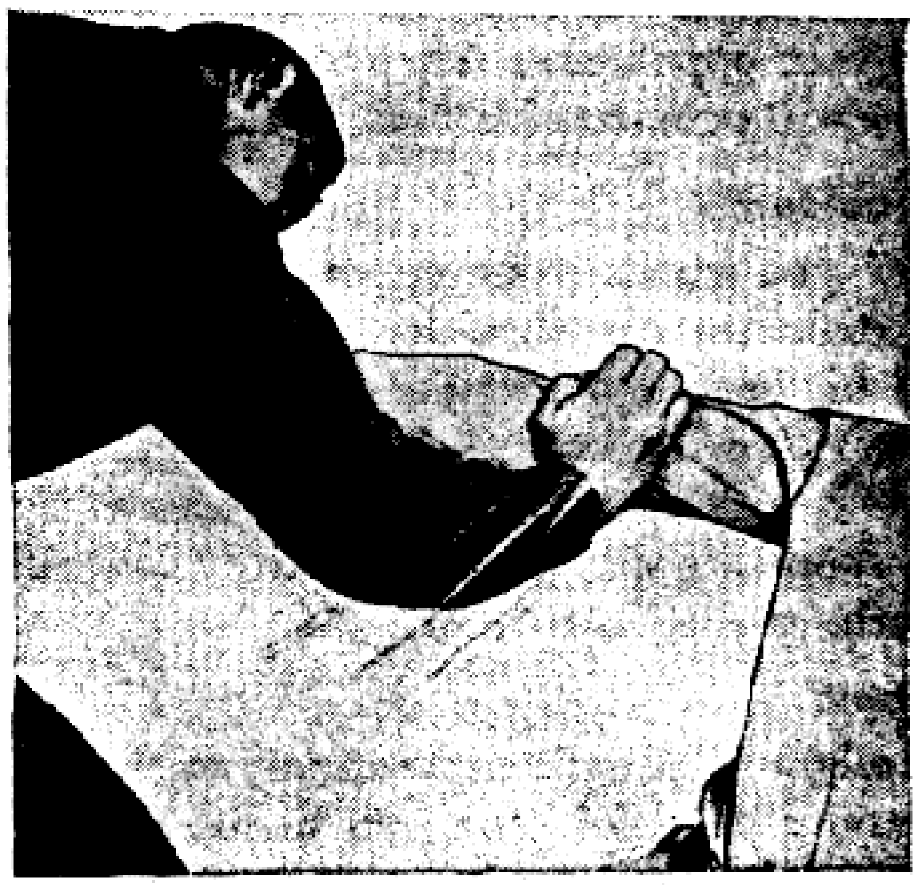

Figure 29. Once an opponent's elbow is broken, he ceases to be dangerous.

31

34. Wrist

Bending the wrist excessively in any direction causes extreme pain. Use a wristlock when attacking this area. Place both your thumbs on the back of your opponent's hand. Bend the wrist at a right angle to his forearm (fig. 30). You can control your opponent when you get him in this position.

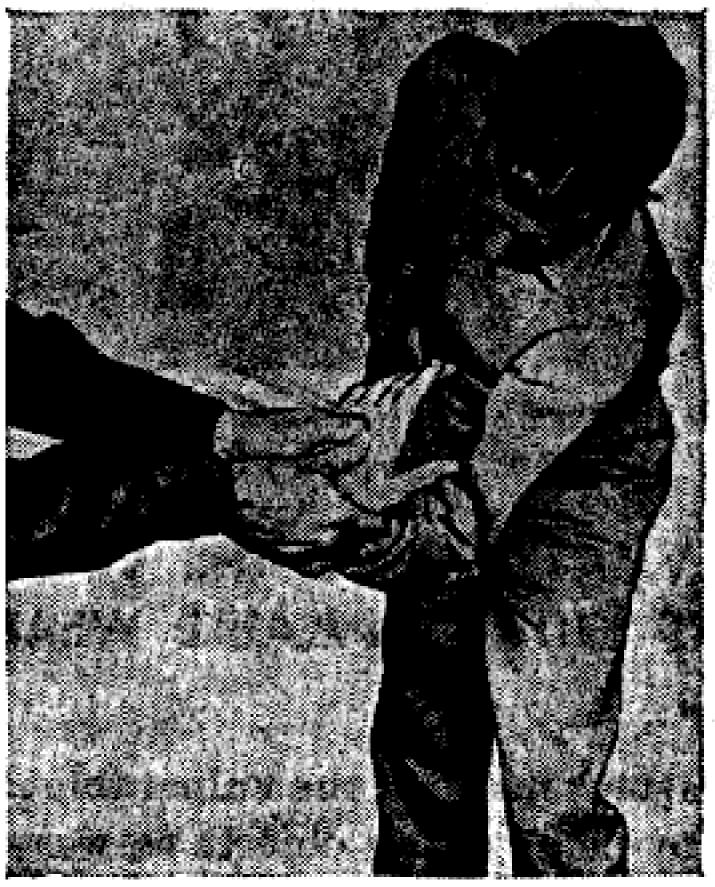

Figure 30. A wristlock produces severe pain. An opponent can be controlled in this position.

35. Fingers

To break an underarm hold around your waist from the rear, grasp any one of your opponent's fingers with one hand while securing his wrist with the other (fig. 31). Push down on his wrist and, at the same time, bend his finger back toward his wrist, This will break his finger.

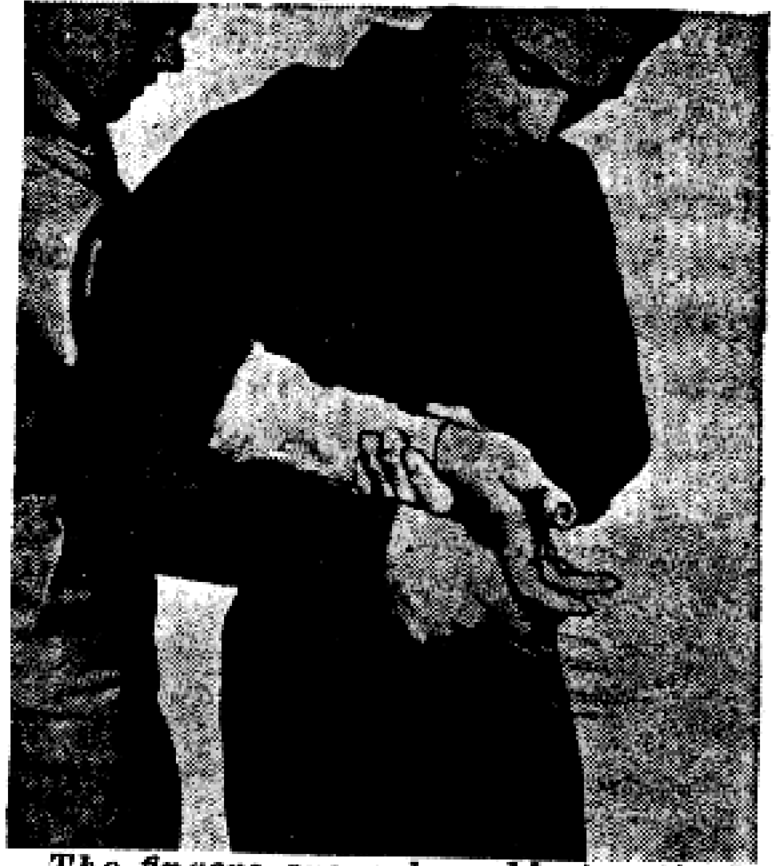

Figure 31. The fingers are vulnerable to attack if an opponent has secured a waist hold.

Section V. ATTACKING THE VULNERABLE POINTS WITH AVAILABLE WEAPONS

36. General

You can attack many of the vulnerable points more effectively by using many objects as weapons.

37. Bayonet Hilt and Tent Peg Knob

Grasp the bayonet or the tent peg so the hilt of the bayonet or the knob of the tent peg protrudes from the little finger edge of your hand (fig. 32).

38. Homemade Blackjack

You can make a blackjack by placing wet sand or a bar of soap in a sock. Tie a knot in the sock just above the sand or the soap. When attacking an opponent, strike him on the back of his head (fig. 33).

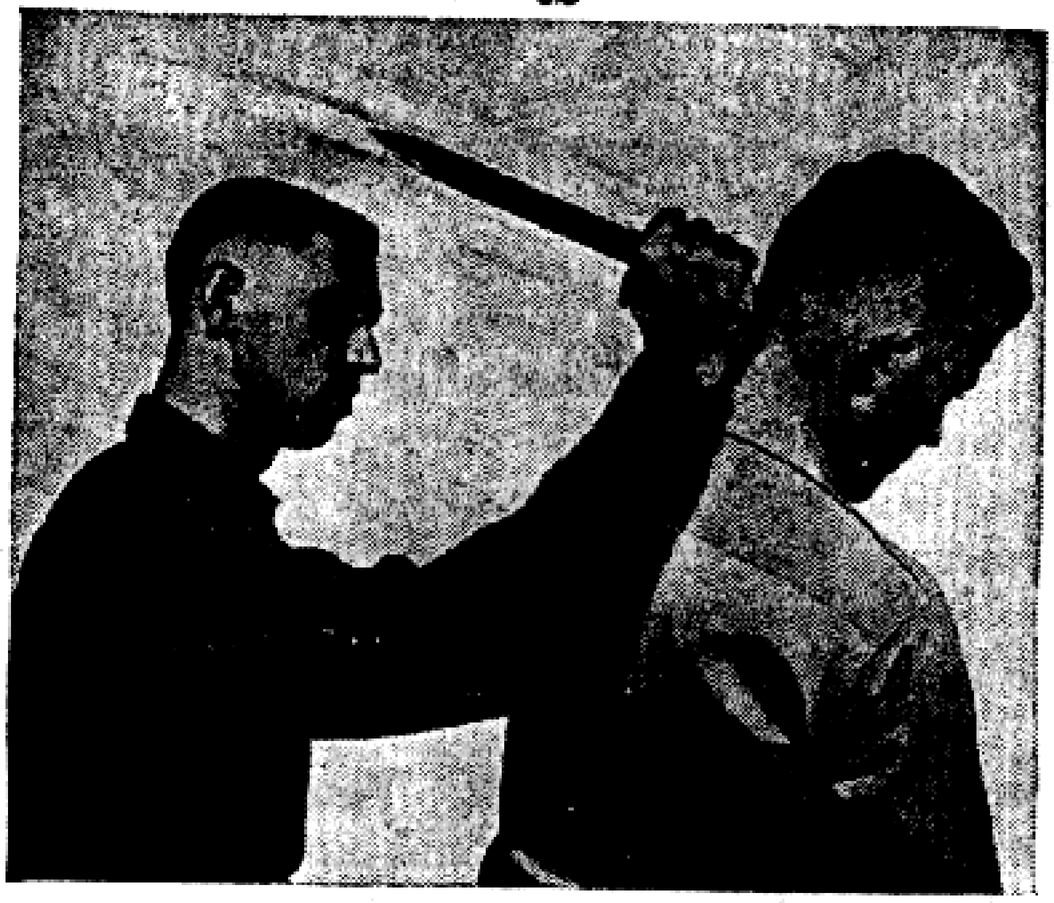

Figure 32. The hilt of the bayonet can be used to silence an enemy sentry.

39. Blunt Objects

By striking your opponent between the shoulder blades on his spine with a blunt object, you can knock him out noiselessly. You can use the blunt end of a hand axe or the butt of a rifle (fig. 34). A blow with the toe of the rifle or the edge of the axe will kill your opponent instead of stunning him.

40. Tent Rope

You can strangle an unsuspecting enemy sentry by using a tent rope or a piece of wire (pars. 50 and 51).

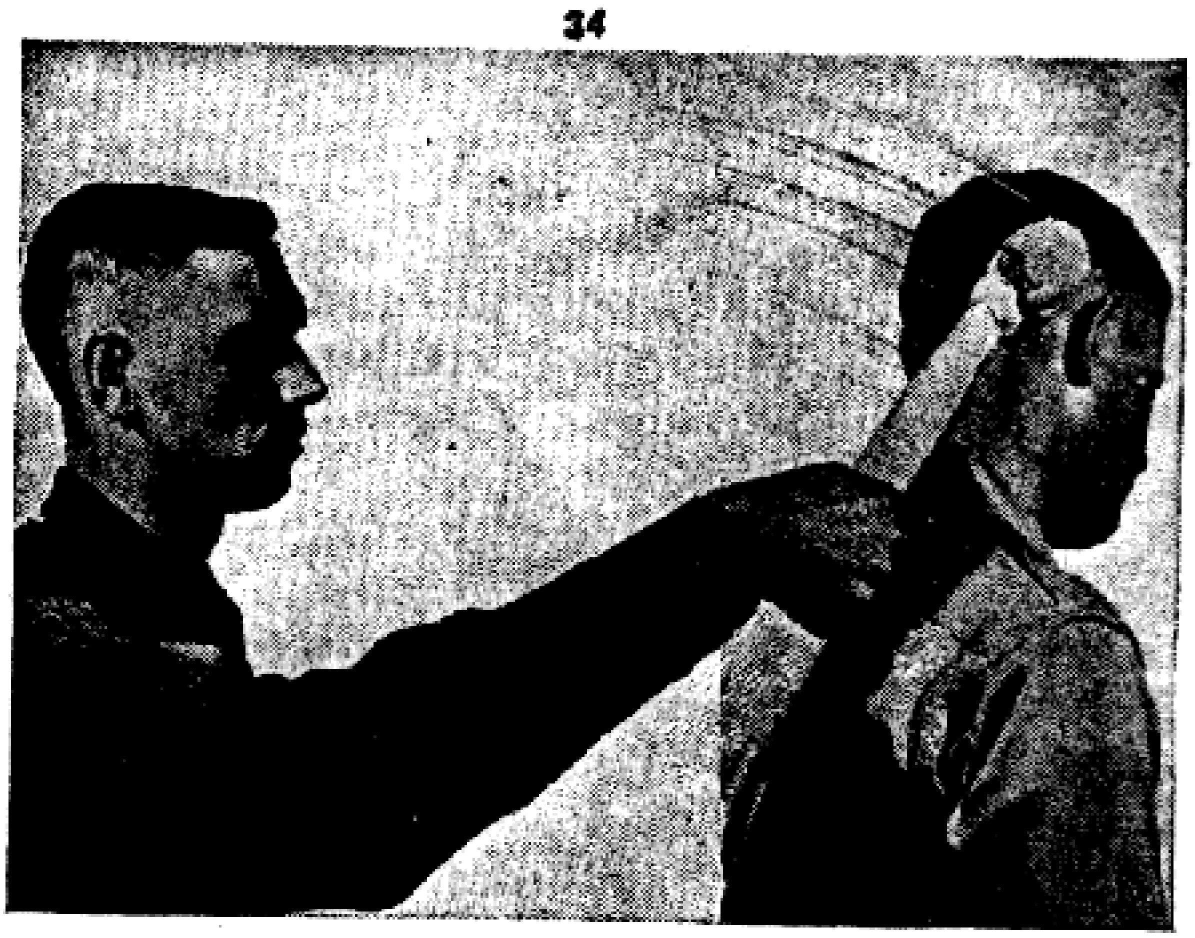

Figure 33. The homemade blackjack is used on many night patrols.

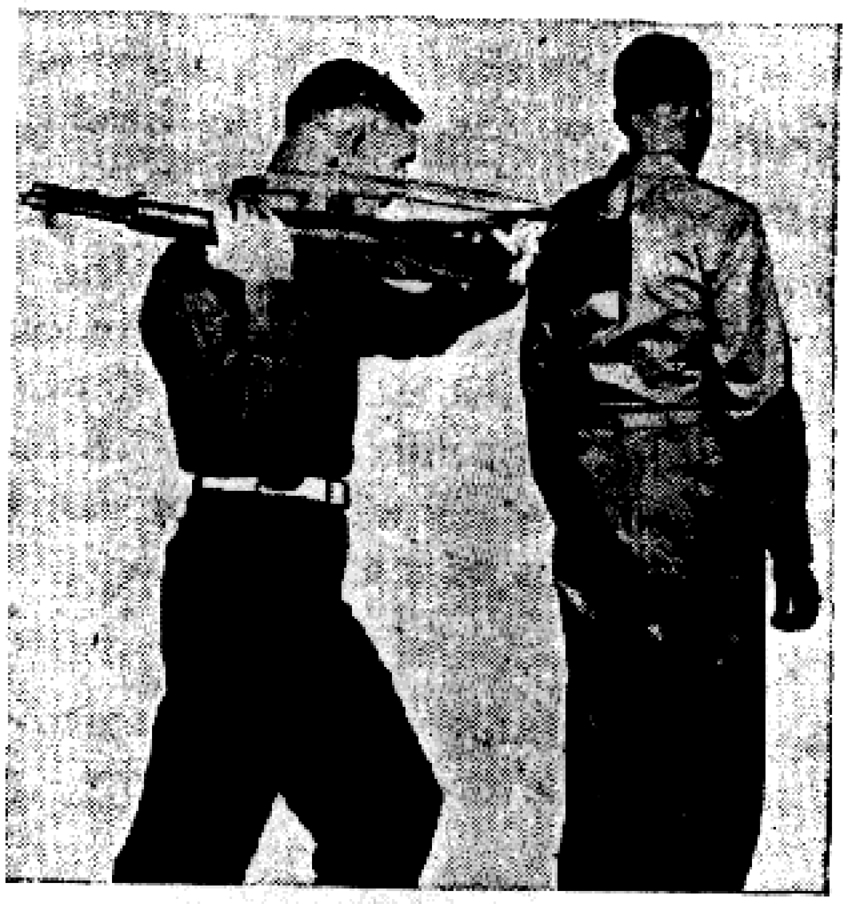

Figure 34. To stun an enemy, use the butt end of the rifle. To kill him, use the toe.

41. Other Weapons

When you find yourself unarmed, you can, on most occasions, find a piece of equipment, a rock, a stick, or a club to use as a weapon. By using these and by attacking viciously, concentrating on your opponent's vulnerable points, you can quickly kill or disable him.

CHAPTER 4

KNIFE ATTACK

42. General

A knife, properly employed, is a most deadly weapon. You can use it on patrols when silence is necessary to prevent an outcry by an enemy sentry, or you can use it for close-in fighting when your rifle or carbine is not available.

43. Grip

To grip the knife properly, lay it diagonally across the outstretched palm of your hand. Grasp the small part of the handle next to the cross guard with your thumb and forefinger. Your middle finger encircles the knife over the handle at its largest diameter (fig. 35). With the knife held in this manner, it is easily maneuvered in all directions. You can control the direction of the blade by a combination movement of the forefinger and middle finger and a turning of the wrist. When the palm is turned up and you are holding the knife in your right hand, you can slash to the right or left. When the palm is turned down, you can also slash in either direction. You can thrust when the palm is held either up or down. When the knife makes contact, it is grasped tightly by all fingers.

44. Stance

When engaging in a knife attack, you are in a crouch with your left hand forward and the knife held close to your body at the right hip (fig. 36). Your outstretched left hand acts as a guard, a foil, or a parry, and it helps create the opening for a slash or a thrust. You may also use your left hand to distract your opponent's attention by waving it in his face, by throwing something, or by making sudden darting motions toward him. When you are in this type crouch, your flexed knees provide extreme mobility and you have good balance. In the crouch, you are also able to protect your midsection and throat area.

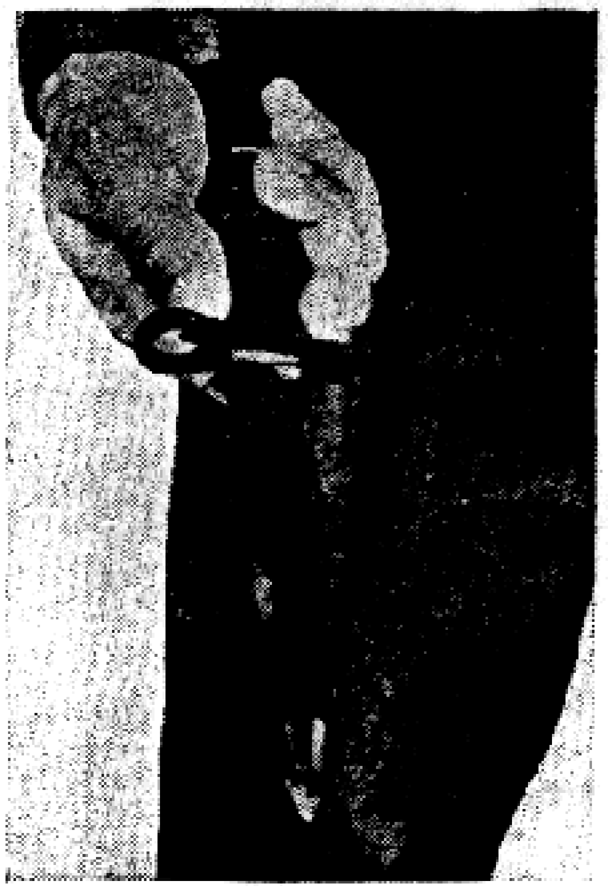

Figure 35. A good grip on a knife is essential for control.

45. Where To Attack

a. When a man is attacked from the front with a knife, he instinctively tries to protect his stomach and throat. If he is wounded in one of these places, his fear is so great that he may forget to defend himself further. His opponent, therefore, can easily kill him.

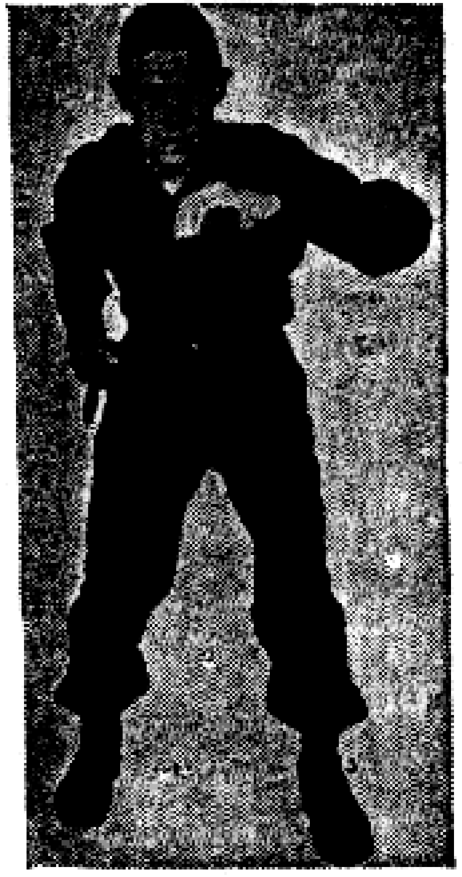

Figure 36. A proper stance provides mobility and good protection.

b. You can attack the throat with either a thrust or a slash. The thrust is the most effective if the knife is driven into the base of the throat just below the Adam's apple (fig. 37). This type blow cuts the jugular vein and results in instant death. A slash to either side of the neck cuts the carotid artery, which carries blood to the brain. Your opponent will die from loss of blood within a few seconds.

c. A thrust (fig. 38) combined with a slash to the stomach produces great shock. Your enemy will be stunned and will forget to defend himself. You can then deliver a killing blow. A deep wound in the stomach causes death if the wound is unattended.

d. A thrust to the heart (fig. 39) causes instant death. This spot, however, is difficult to hit because

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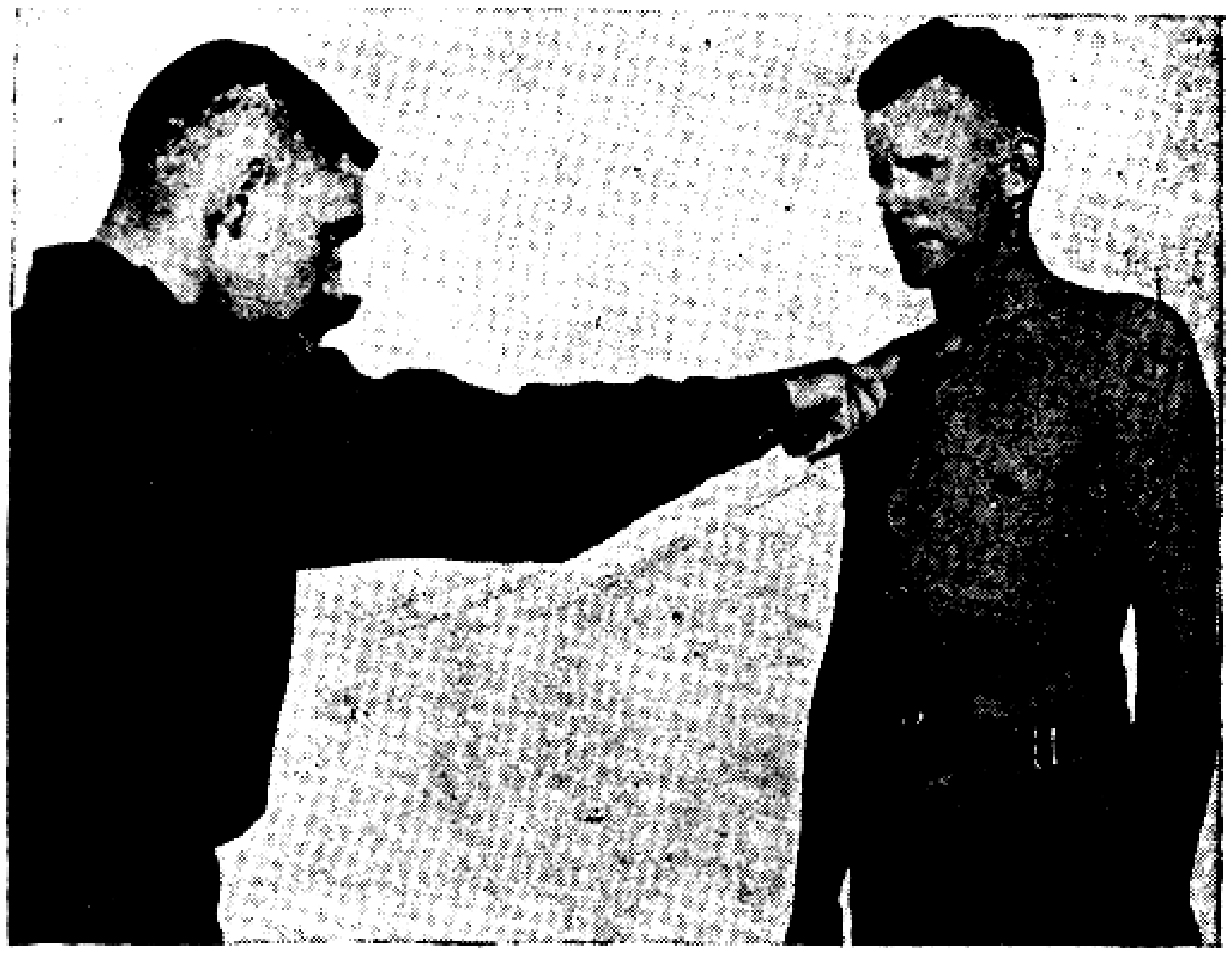

Figure 37. An enemy will die immediately if a knife is thrust into the base of his throat.

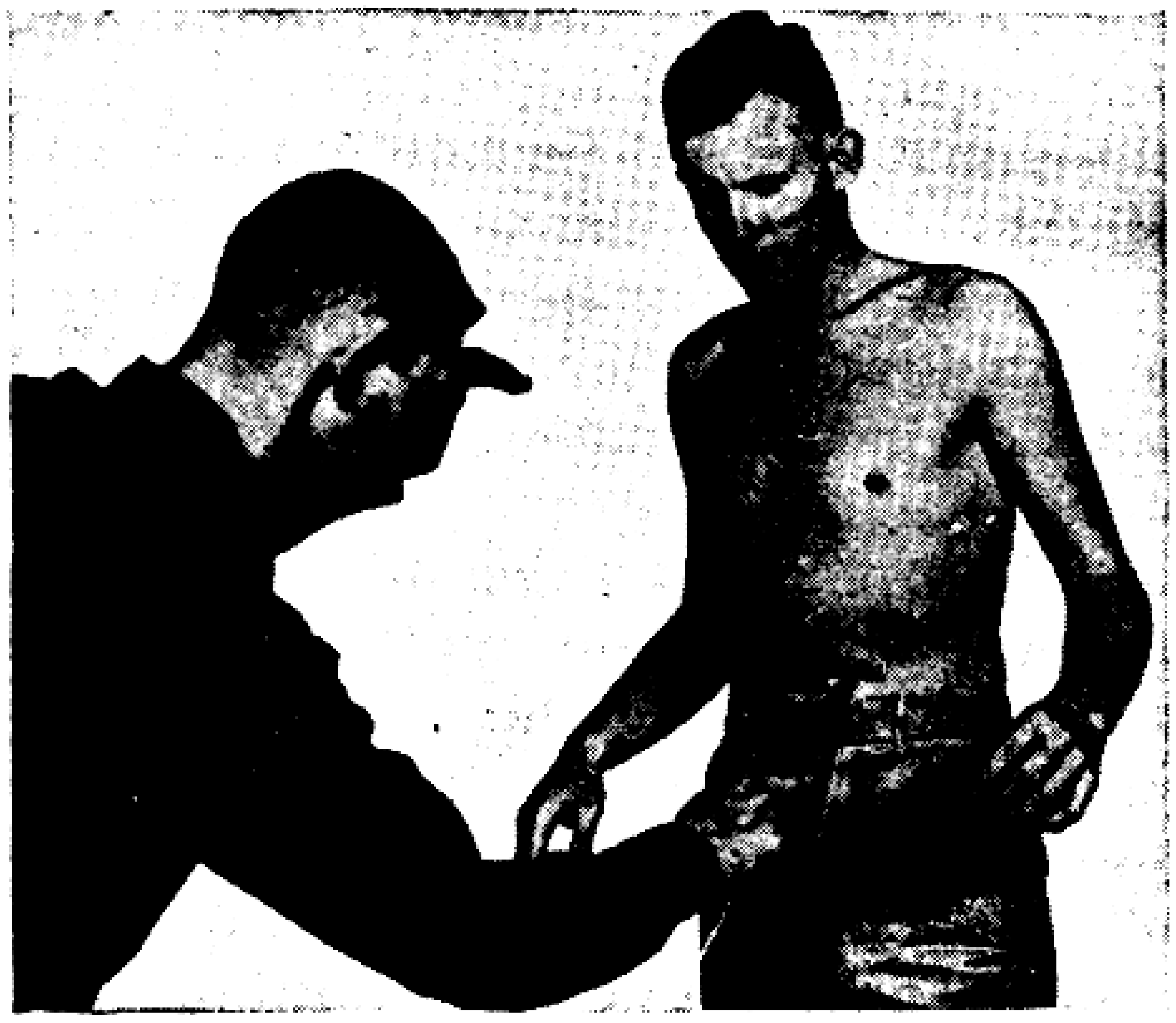

Figure 38. A thrust to the stomach produces great shock.

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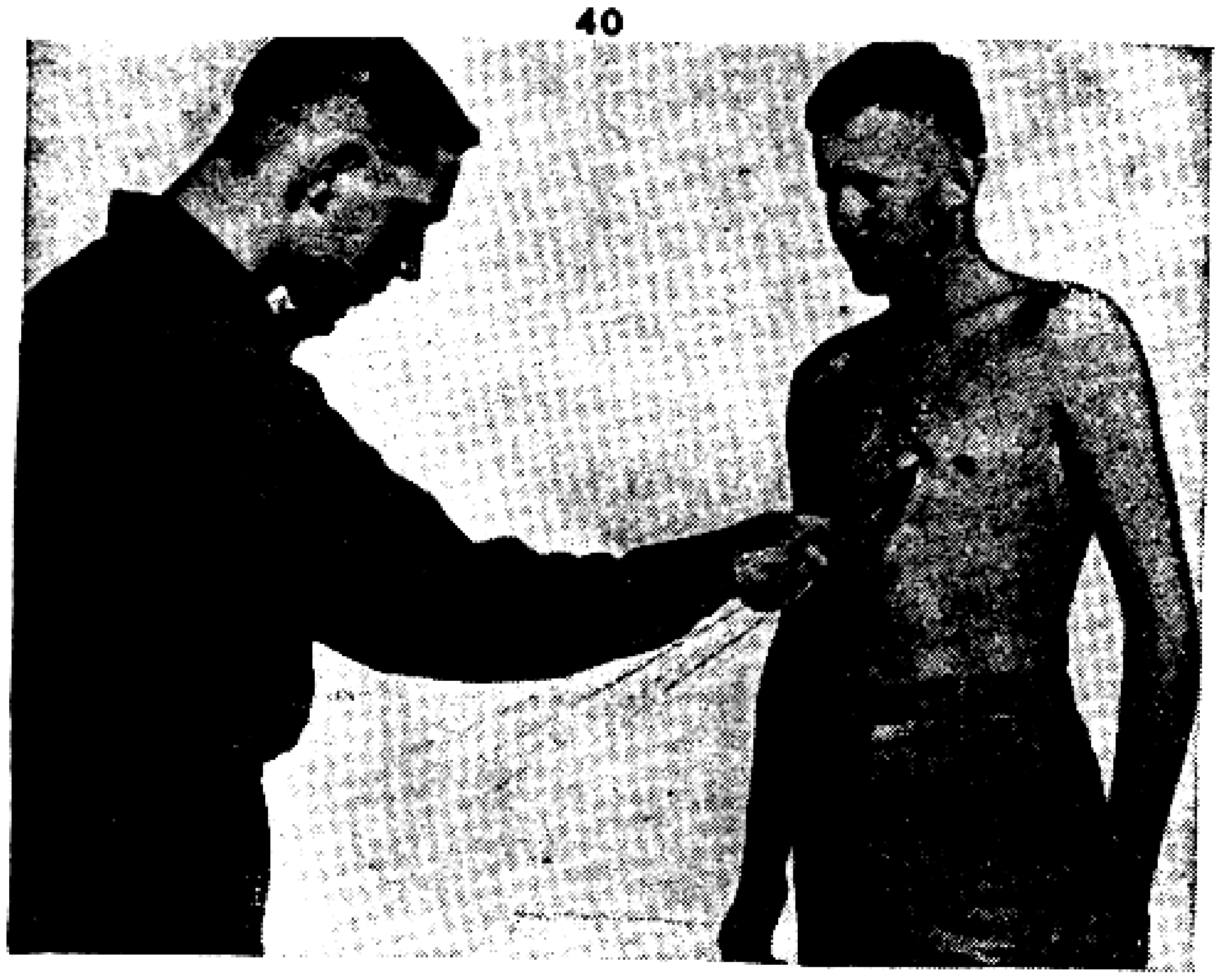

Figure 39. A thrust to the heart causes instant death. The heart, however, is protected by ribs.

of the protecting ribs. Usually, a hard thrust will slip off the rib and penetrate the heart.

e. A slash to the wrist (fig. 40) will sever the radial artery, causing death within two minutes. This type attack is excellent if your opponent attempts to grasp your clothing or arm. The radial artery is only one-quarter inch below the surface of the skin. Unconsciousness results in about 30 seconds.

f. A slash to the upper arm just above the inside of the elbow (fig. 41) cuts the brachial artery and causes death within 2 minutes. This artery is about one-half inch below the skin surface. Unconsciousness occurs in about 15 seconds.

g. A slash to the inside of the leg near the groin (fig. 42) severs the arteries there and makes that limb useless.

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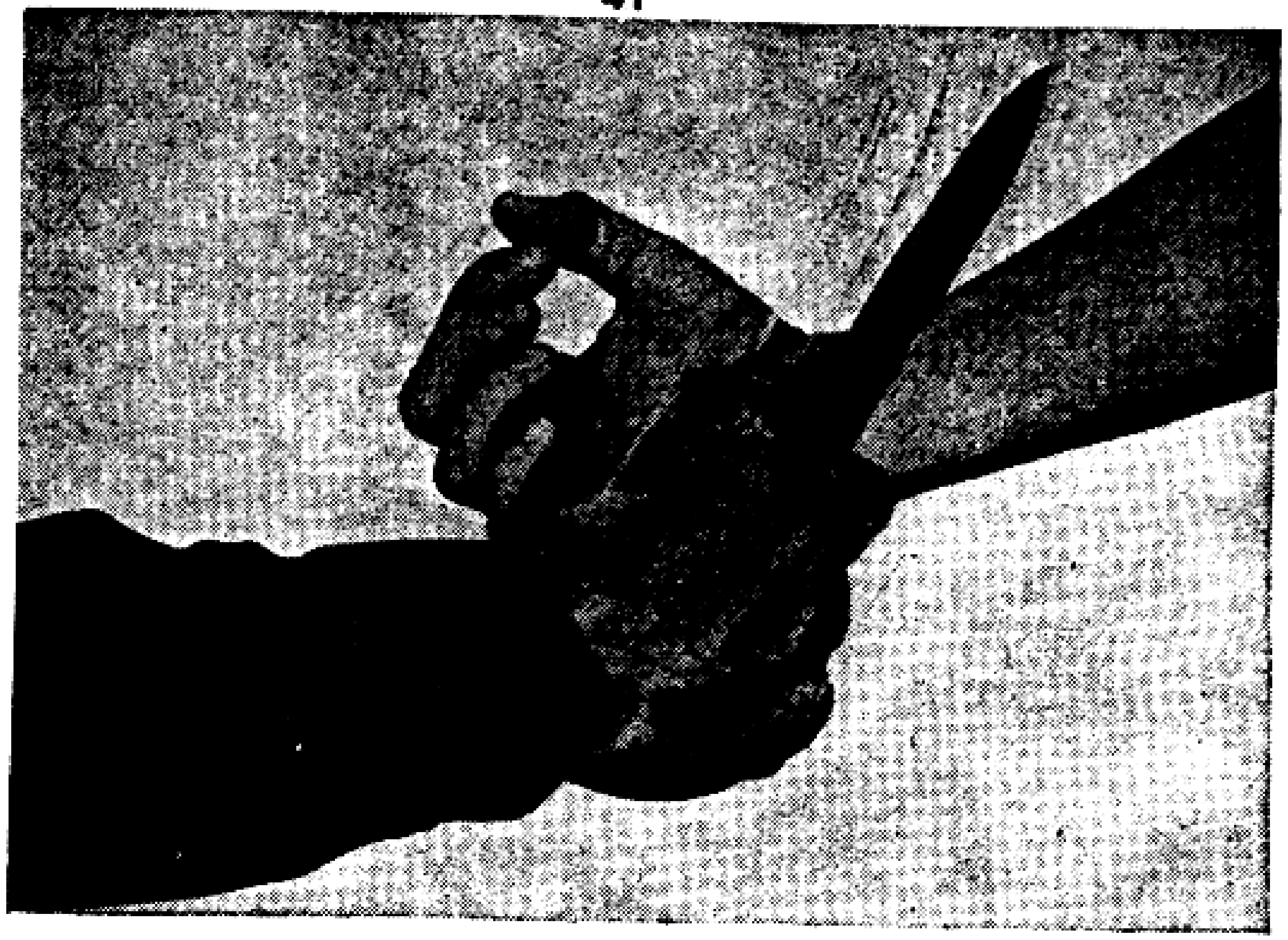

Figure 40. A slash to the wrist cuts the radial artery and will kill an enemy within two minutes.

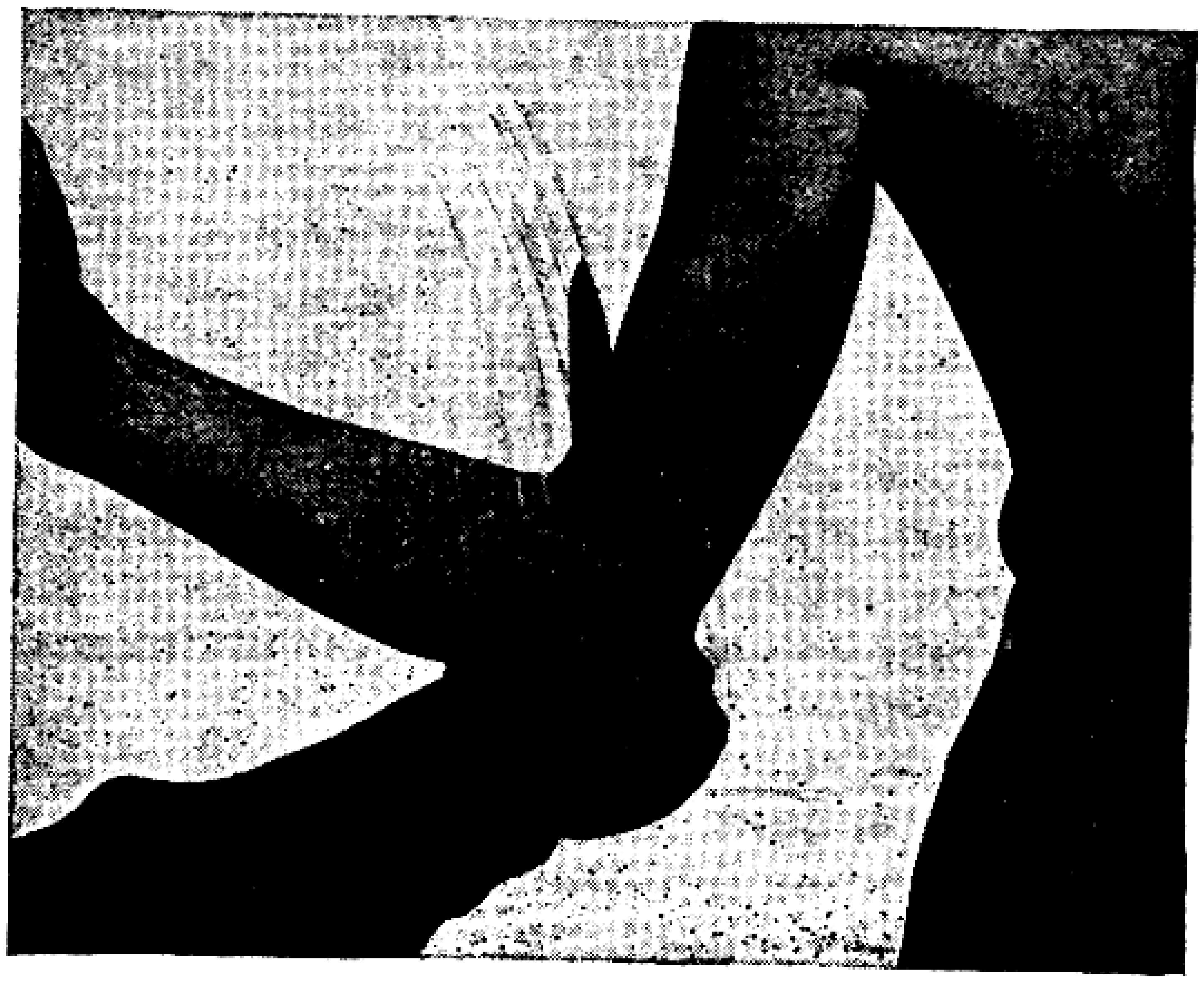

Figure 41. The upper arm is vulnerable to a slash.

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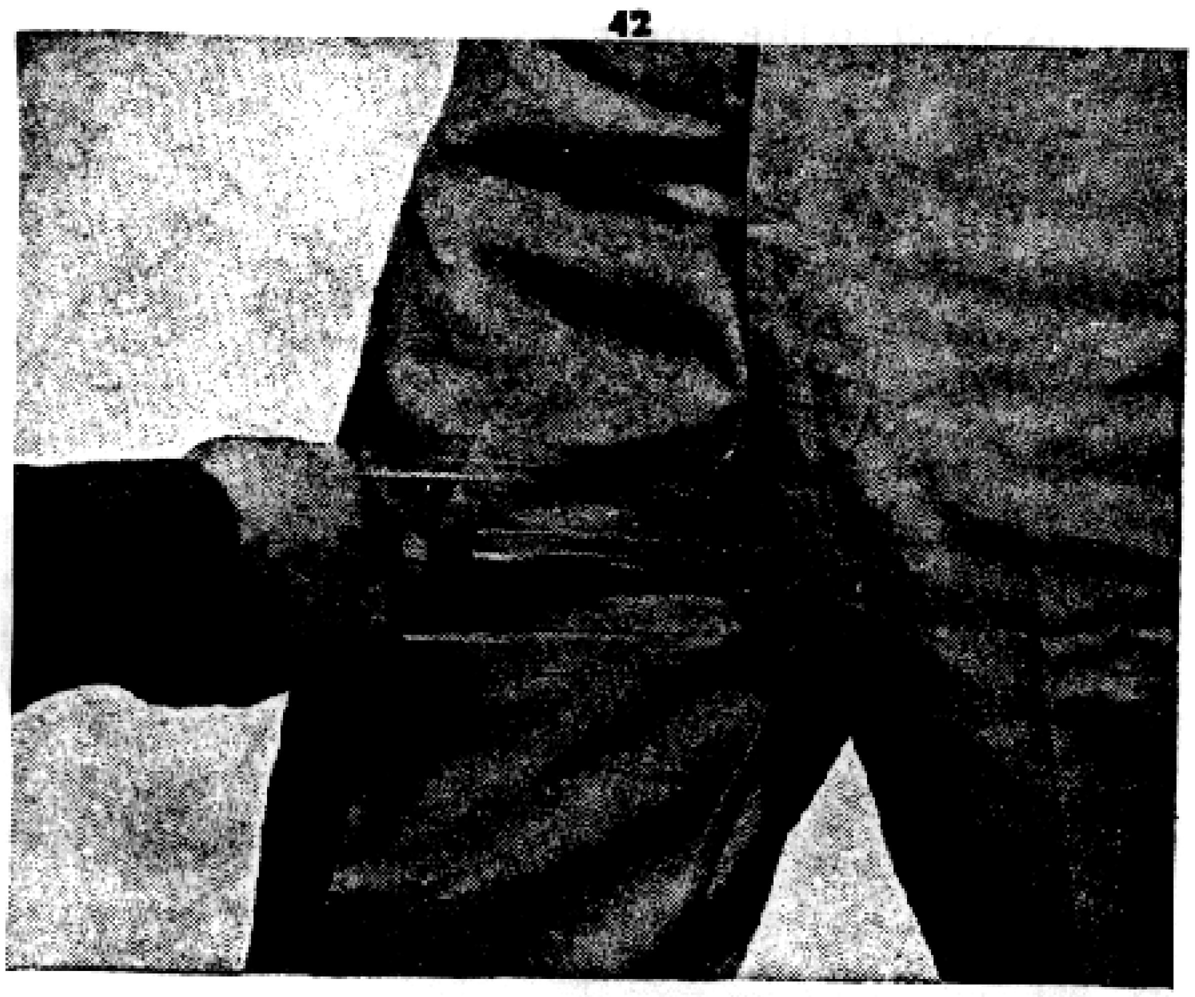

Figure 42. A slash to the inside of the leg will immobilize an opponent.

46. Attack From the Rear

a. To attack an enemy from the rear, you launch your attack immediately on reaching a position not less than 5 feet from him. Thrust the knife into his right or left kidney and simultaneously grasp his mouth and nose with the other hand (fig. 43). After a short interval, withdraw the blade, slashing as you do so, and cut his throat. The thrust to the kidney produces great shock and causes internal hemorrhage and death.

b. A thrust into the side of the neck (fig. 44 ①) is also effective when you want to maintain silence. A slash across the neck from the rear (fig. 44 ②) severs the windpipe and jugular vein.

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c. The subclavian artery is approximately 2½ inches below the surface between the collar bone and shoulder blade (fig. 45). Attack this spot with a thrust by gripping the knife as you would an ice pick. As you withdraw the knife, slash to make the wound as large as possible. This artery is difficult to hit, but once it is cut, the bleeding cannot be stopped and your opponent will lose consciousness within seconds. Death will follow rapidly.

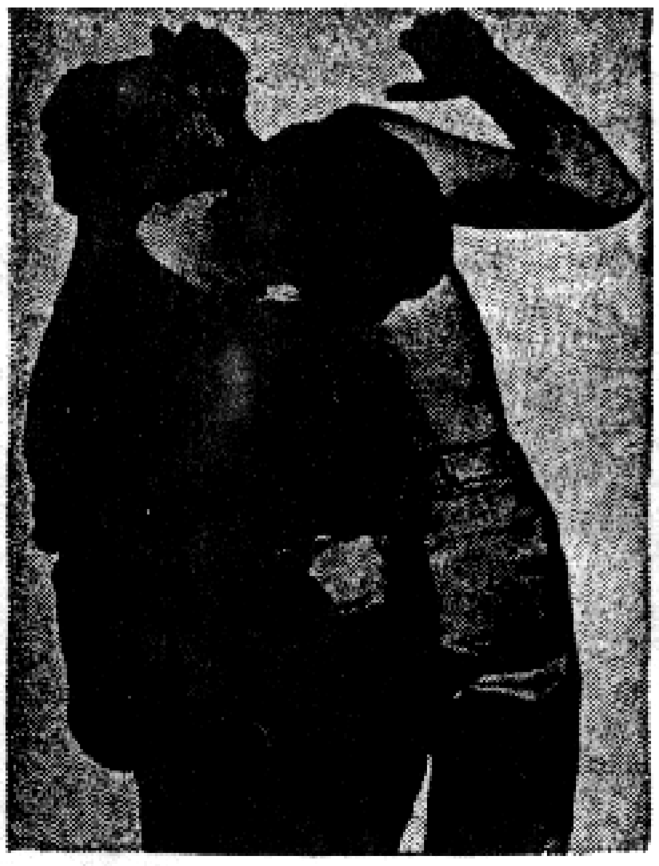

Figure 43. A thrust to the kidney from the rear disposes of an enemy silently.

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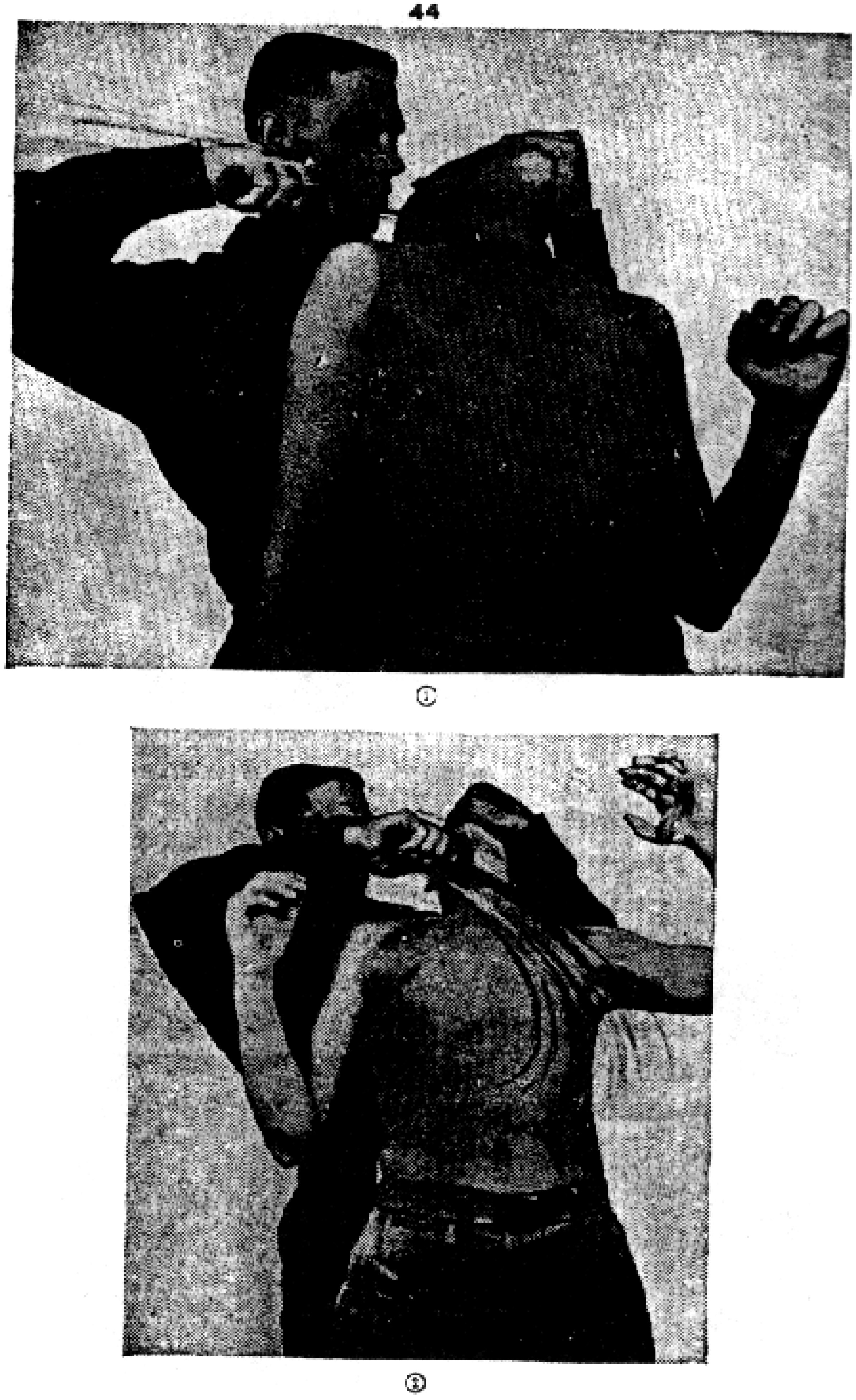

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Figure 44. A thrust or a slash to the neck from the rear kills an enemy quickly and silently.

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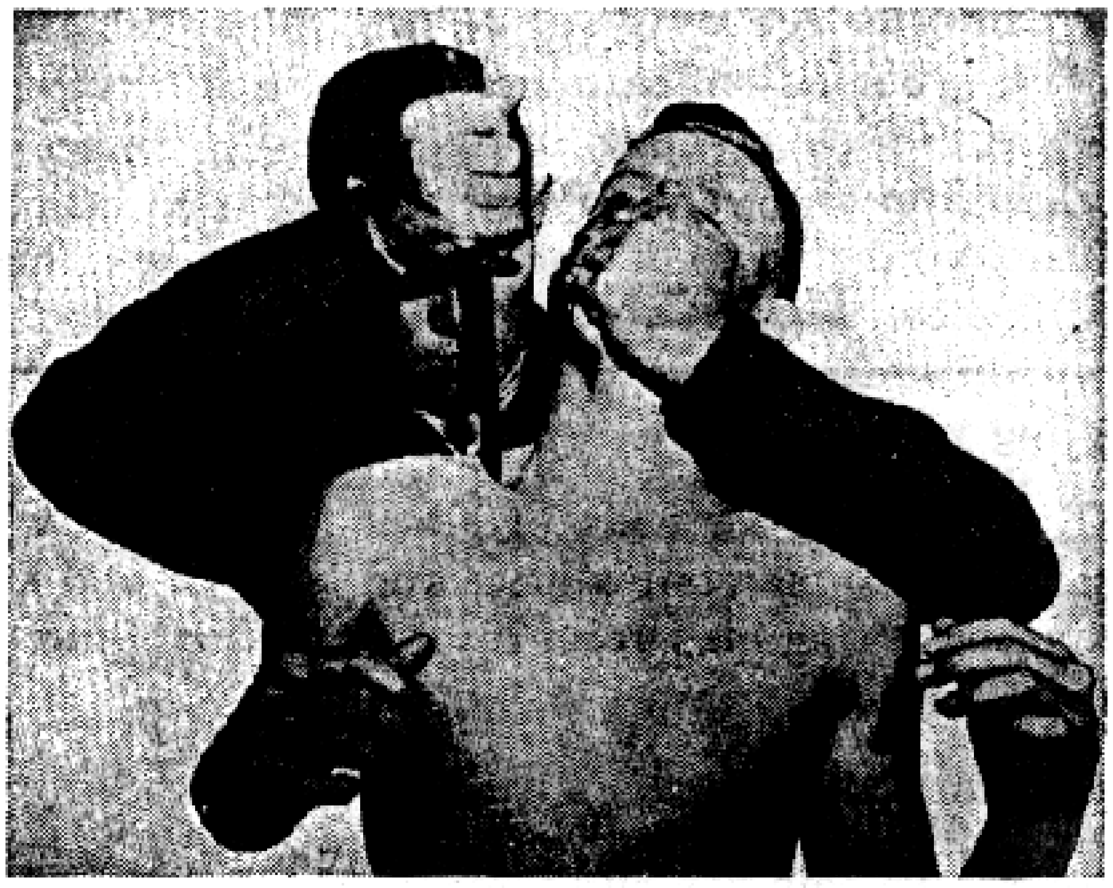

Figure 45. Attacking the subclavian artery.

46

CHAPTER 5

SILENCING SENTRIES

47. General

Knowing the methods of silencing sentries will enable you to maintain silence and surprise and kill an unsuspecting man from his rear quickly, quietly, and efficiently.

48. Helmet Neck Break

Grasp the front rim of your opponent's helmet with your right hand. At the same time, place your left forearm against the back of his neck and place your left hand on his right shoulder (fig. 46 ①). Holding firmly to the front rim of your opponent's helmet, pull his helmet up, back, and down and press your left forearm forward (fig. 46 ②). Your left forearm, under the back edge of his helmet, acts as a fulcrum against which his neck is broken. This method is possible only when your opponent's helmet strap is fastened underneath his chin.

49. Helmet Smash

If you see that your opponent's helmet strap is not fastened or should you discover this when attempting the helmet neck break, silence the man with a helmet smash. Pull your opponent's helmet quickly from his head. While doing this, grasp his collar with your other hand, jerking him off balance to his rear (fig. 47 ①). Then smash the helmet to the back of his head or at the back of his neck (fig. 47 ②).

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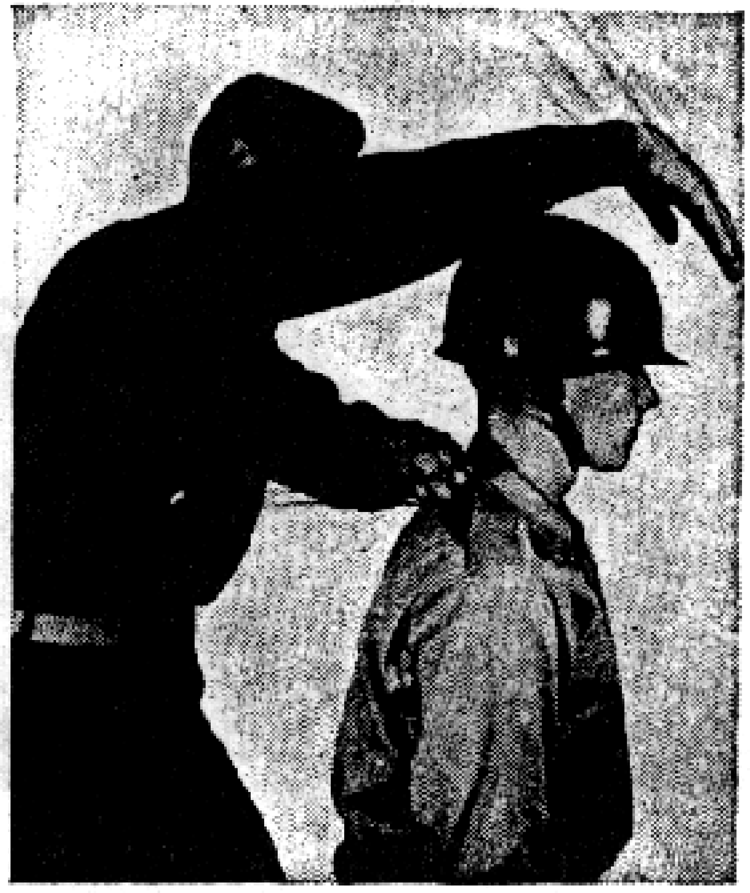

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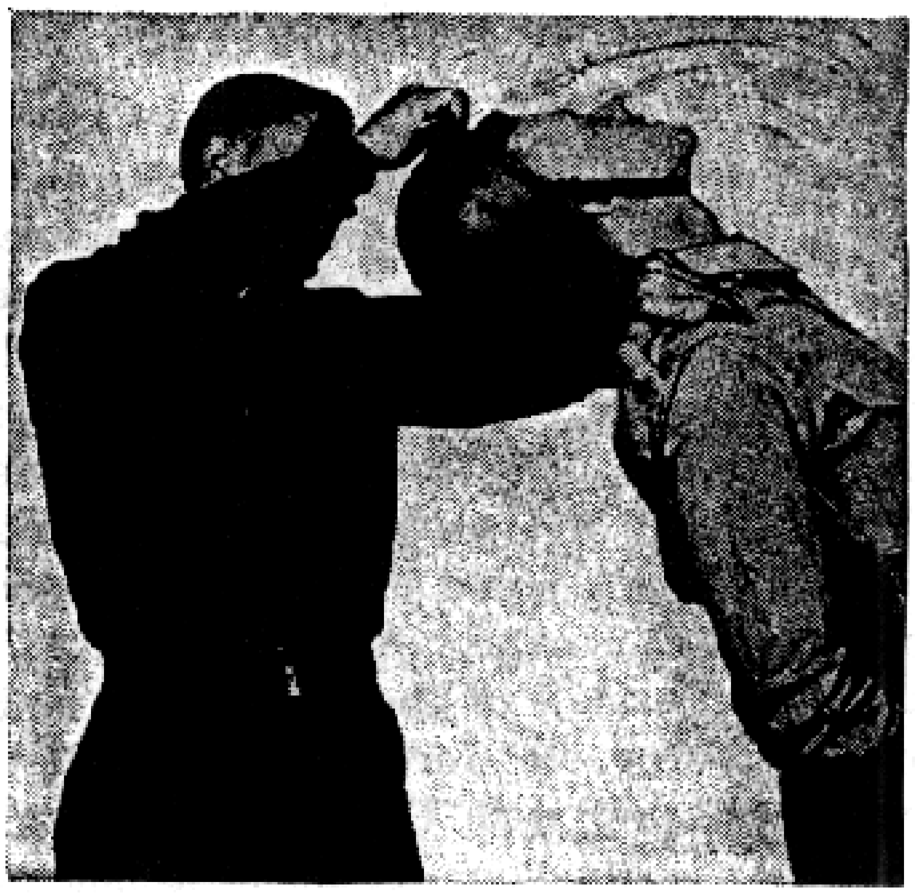

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Figure 46. The helmet neck break.

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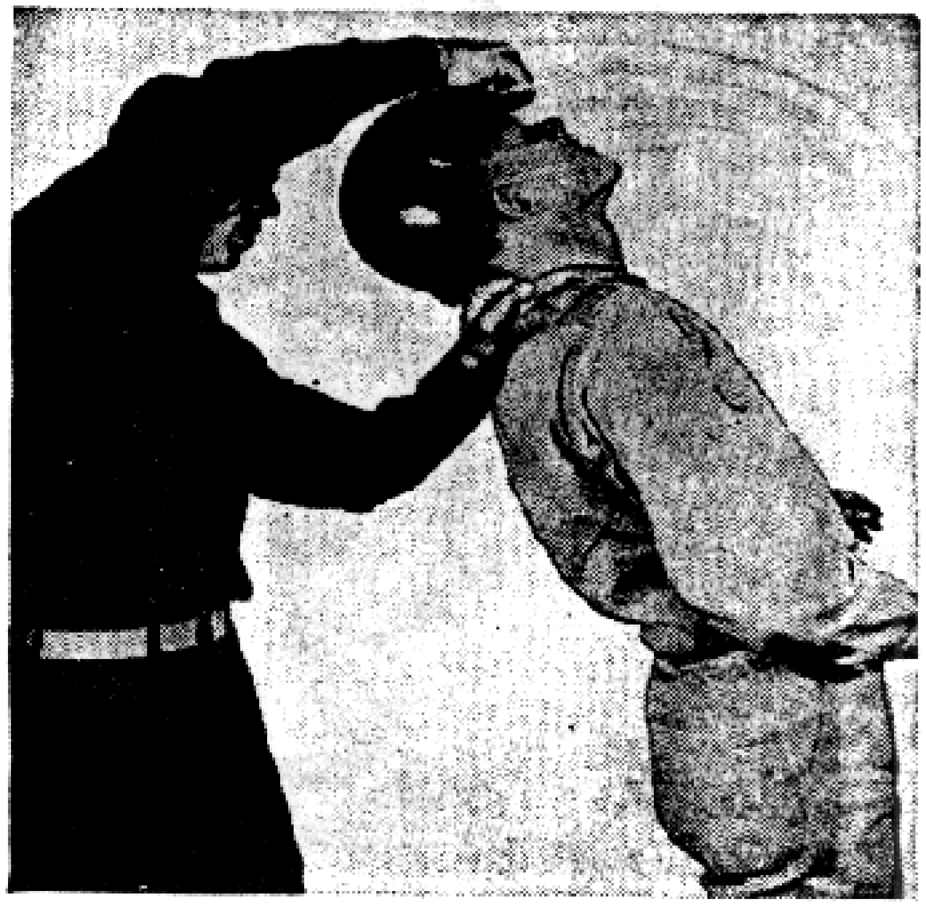

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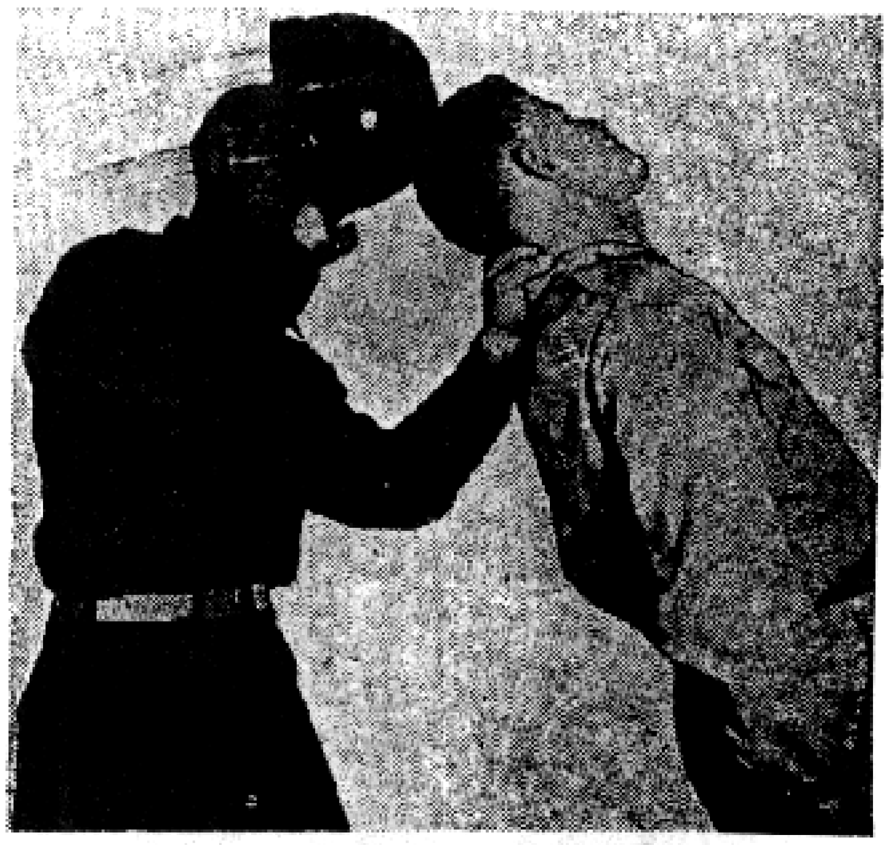


Figure 47. Use the helmet smash when an opponent's helmet strap is not fastened.

Your opponent may have a chance to yell when this method is used.

50. Strangulation With Wire or Cord

For this method of strangling an opponent to death, you need a piece of flexible wire or a piece of cord about three feet in length. Approach the enemy from his rear, holding an end of the wire or cord in each hand. Toss the wire or cord over his neck from his left and place the heel of your left hand, still holding the end of the wire or cord, on his shoulder near his nape. At the same time, place your knee in the small of the man's back and pull back on the cord or wire forcefully with your right hand while pushing with the left hand (fig. 48). If this is done quickly, your opponent cannot cry out. You can tie the ends of the rope or wire around two short sticks for a better hold.

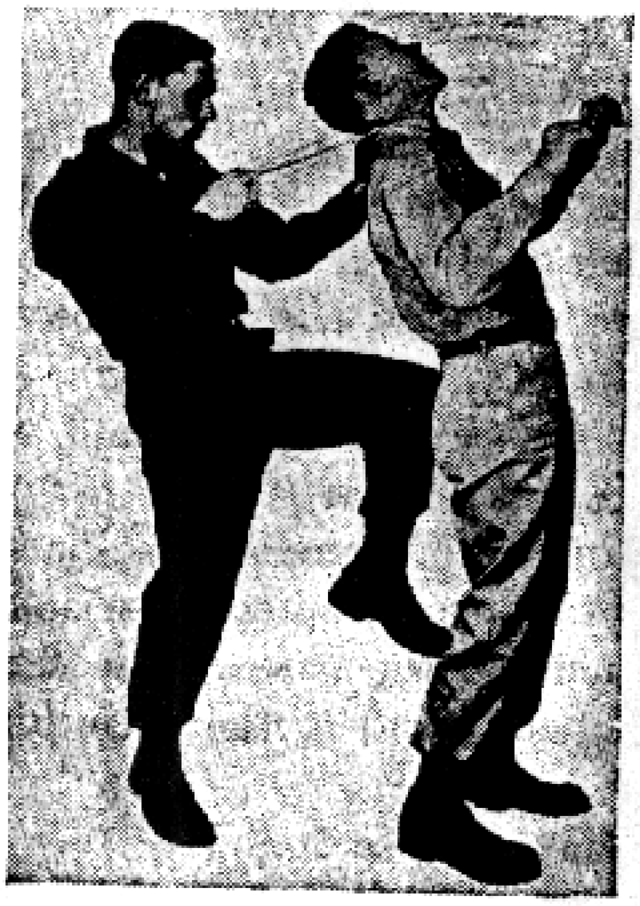


Figure 48. A piece of wire or cord is a silent weapon.

51. Two Hand Loop

Hold an end of the wire or cord in each hand. Place your left forearm across the back of your opponent's neck as shown in figure 49 ①. Swing your right arm over your opponent's head from his right, looping the wire or cord in front of his throat. Complete the loop and jerk your arms sharply in opposite directions, tightening the loop and strangling your opponent (fig. 49 ②). Quick application of this method prevents your opponent from crying out. You can cause unconsciousness or death, depending on the force used and the length of time the hold is applied.

52. Other Methods

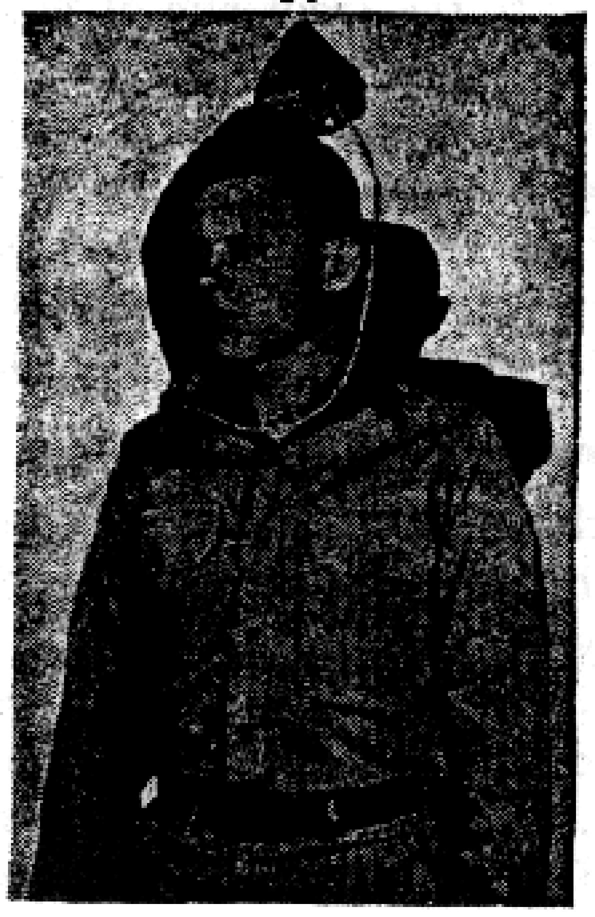
Other methods of silencing sentries can be found throughout this manual under other chapter headings. To help you find these methods, a list of them and the chapters and paragraphs where they are found are given below.

a. Knife attack, chapter 4.
  (1) Thrust to kidney (par. 46*a*).
  (2) Thrust to side of neck (par. 46*b*).
  (3) Throat slash (par. 46*b*).

b. Available weapons, chapter 3, section V.
  (1) Striking an opponent on his spine with a blunt object to stun him and with a sharp object to kill (par. 39).
  (2) Use of the homemade blackjack (par. 38).

c. Natural weapons, chapter 3, section II. Striking an opponent on the base of the skull with the knife edge of your hand or the little finger edge of your fist (par. 16).

d. Holds, chapter 7, section I.
  (1) Taking a man down from his rear (par. 69).
  (2) Locked rear strangle hold (par. 73).



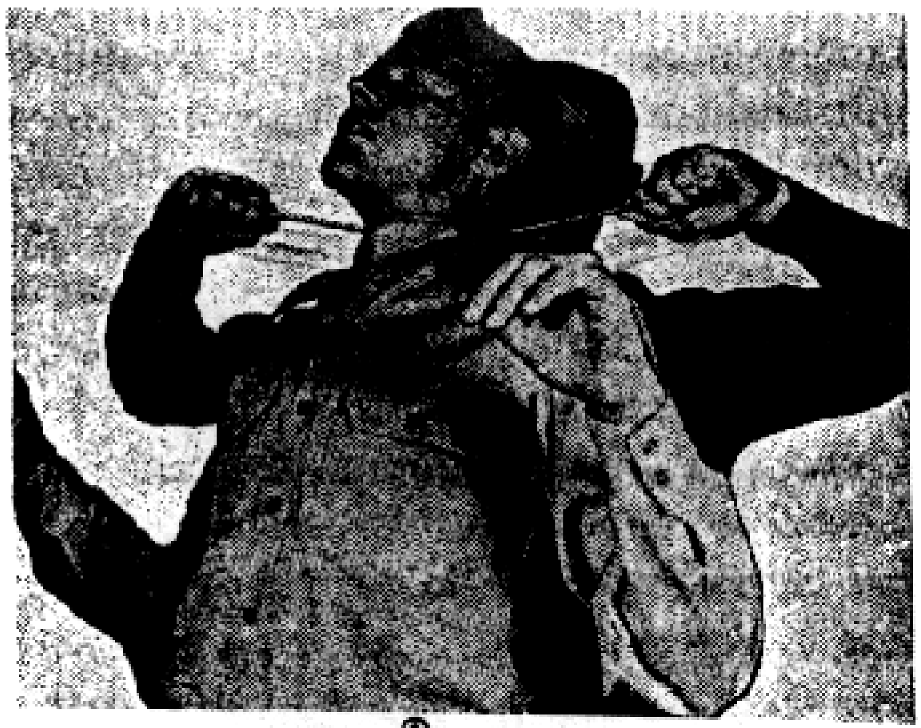


Figure 49. The two hand loop method of strangulation is quick and silent.

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CHAPTER 6
FALL POSITIONS AND THROWS

Section I. SIDE FALL POSITIONS

53. General

You must learn various fall positions before you attempt the throws that are taught in unarmed combat. Constant practice in these positions will enable you to be thrown without being injured.

54. Left Side Fall Position

Figure 50 shows the left side fall position. The check points for this position are—

a. Your right foot is driven to the ground, taking up the initial shock of the fall. It strikes the ground before your body and is crossed over your left leg at the knee. The sole of your foot is flat on the ground.

b. Your left arm is the "beating" arm and takes up additional shock. It is extended along the ground, palm down, at an angle of 45° to the body. This arm makes contact with the ground at the same time your "shock absorber" foot does.

c. Your chin is tucked into your chest. Keep your neck tense to prevent your head from being injured.

d. Your right arm is folded across your chest. This prevents injury to your right elbow and offers some protection to the head and body from the blows of your opponent.

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e. The entire left side of your body makes solid contact with the ground. To relax your left leg, bend it slightly to prevent it from being injured.

f. The check points for the right side fall position are the same as those for the left side fall position. Simply substitute the words "right" for "left" and "left" for "right."

55. Practicing the Falls

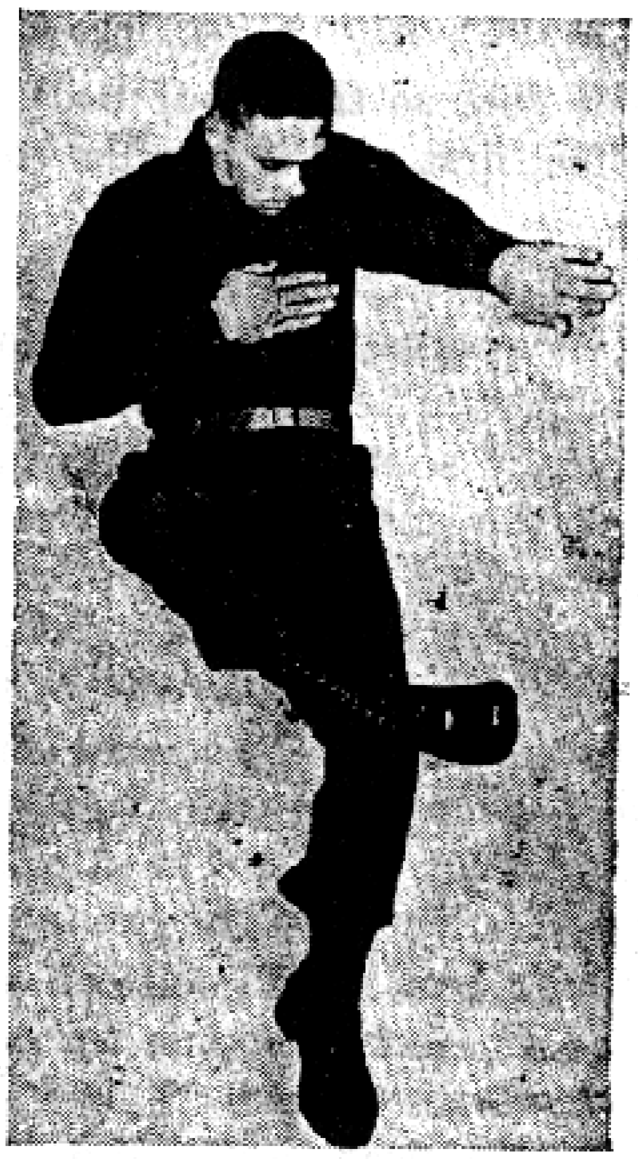

Figure 50. Every soldier must learn how to fall properly to prevent injury.

54

a. Figure 51 illustrates a method of practicing the fall positions. Your training partner assumes a position on his hands and knees. Lie with your back across his back and position your legs and right arm into the proper position for the fall. Fold your left arm across your chest.

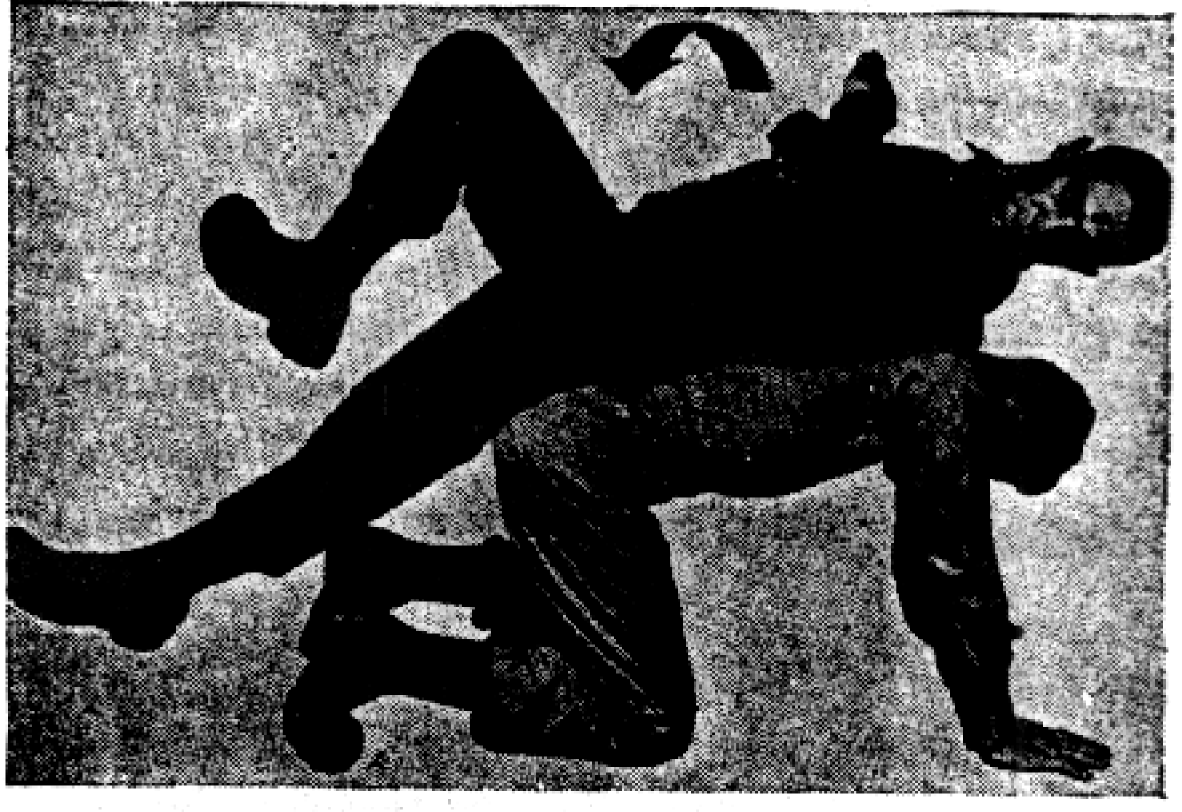

Figure 51. A basic way to practice the left side fall position is to fall off a training partner's back in the proper position.

b. Watch the ground over your left shoulder and swing your left arm forcefully to your left, rolling off your partner's back. Your left hand and right foot strike the ground first, taking up the initial shock of the fall. The right side fall position can be practiced in a similar manner.

56. Advanced Falling Practice

a. Start from the guard position. Take several steps forward to build up momentum. When your left foot strikes the ground, kick your right leg vigorously into the air. At the same time, thrust with your left foot so that your body is propelled into the air, feet first, and is parallel to the ground.

55

While in midair, twist your body 90° to the left and, at the same time, cross your right foot over your left leg at the knee. The sole of your right foot faces toward the ground so it will strike the ground first, thus taking up the initial shock of the fall. While still in the air, extend your left arm in front and at a 45° angle to your body. Your palm is down to take up the additional shock of the fall and to prevent injury to the elbow. Tuck your chin into your chest and fold your right arm across your chest. This prevents injury to your head and right arm when you make contact with the ground. When you strike the ground, you have good contact along the entire left side of the body, your right foot having absorbed most of the shock. The right side fall position can be practiced in a similar manner.

b. Start from the right side fall position on the ground. Push off the ground vigorously with your left foot and right arm in order to turn your body to the left side. During the turn, pull your knees against your chest and thrust them vigorously upward and outward at an angle of 15° so that your entire body is lifted off the ground. Once you are in the air, twist 90° to your left, assuming the left side fall position. By completely clearing the ground when changing from the right to the left side fall position, you obtain practice in absorbing landing shock. The right side fall position can be practiced from the left side in a similar manner.

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Section II. OVER SHOULDER THROW FALL POSITION

57. From a Standing Position

Use this fall position when your opponent throws you over his shoulder. To practice this fall position, start from the guard position. Take several steps forward to build up momentum, and then assume a squatting position as if going into a forward roll. Place your hands between your knees, with the palms flat on the ground. Arch your back and tuck your chin into your chest to keep your head from striking the ground (fig. 52 ①). Roll forward in a somersault. At the peak of the forward roll, drive the soles of the feet to the ground about shoulder's width apart, keeping your lower legs at a 90° angle to the ground. This takes up the initial shock of the fall. Keep your stomach muscles tightened so your buttocks will not strike the ground when you land. At the same time your feet strike the ground, slap both hands to the ground. The arms are fully extended and the palms down, forming a 45° angle to your body. This slapping motion gives you contact with the ground along both arms and across the shoulders, taking up the fall's additional shock (fig. 52 ②). After completing the fall, check the following points:

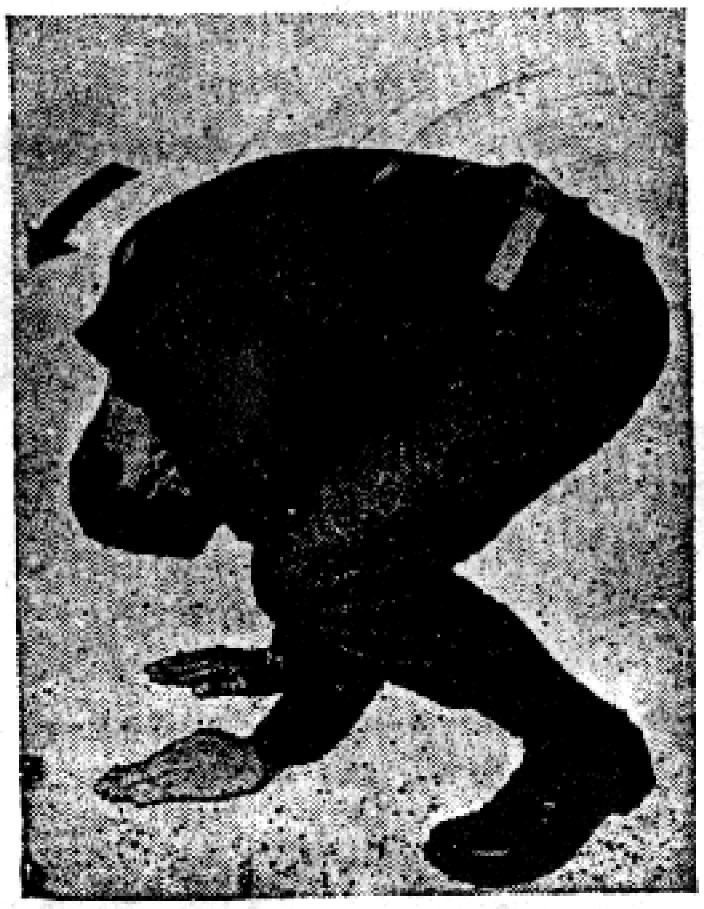

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***Figure 52.** The over shoulder throw fall position.*

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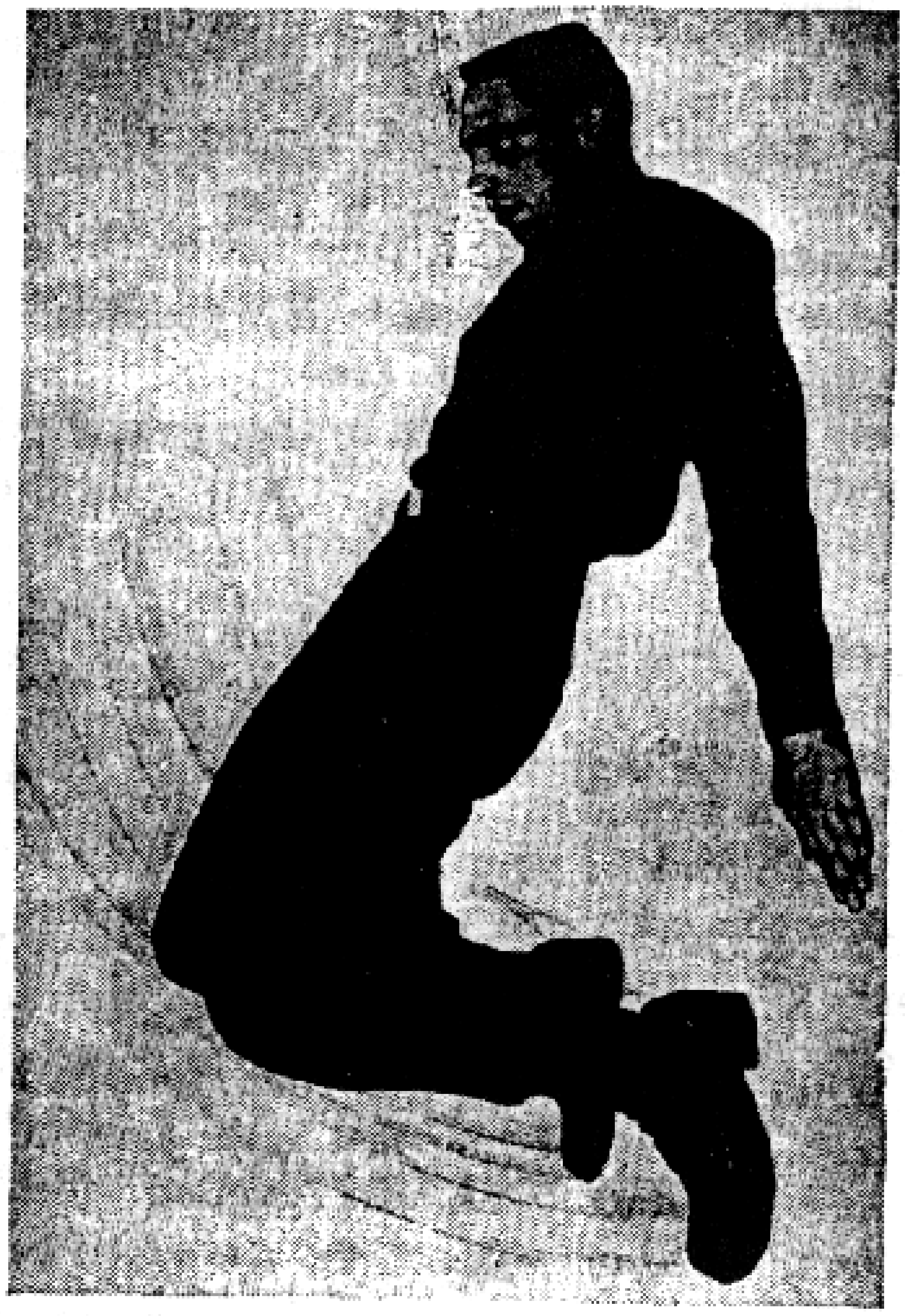

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Figure 52—Continued.

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a. Are the soles of both feet flat on the ground?

b. Are the lower legs at a 90° angle to the ground?

c. Are the buttocks well off the ground?

d. Is the chin tucked into the chest?

e. Are the shoulders and arms flat on the ground, palms down, with the arms at a 45° angle to the body?

58. From the Ground

To practice the over shoulder throw fall position without coming to a standing position, do the following:

a. Lie down on the ground, draw your knees up to your chest, fold your arms across your chest, and rock into a sitting position.

b. Roll backward as if going into a backward roll.

c. At the peak of your backward roll (when your shoulders touch the ground), thrust your feet vigorously upward and outward at an angle of 15°, raising your body completely off the ground.

d. While in midair, tighten your stomach muscles and strike the soles of your feet to the ground.

e. Make contact with the ground with your shoulders, arms, and soles of the feet all at the same time.

Section III. BASIC THROWS

59. General

At times in hand-to-hand combat, you have to throw your opponent to the ground before you can attack a vulnerable part of his body. Three basic throws used are the right hip throw, the over shoulder throw, and the reverse hip throw. Variations of these throws can be used and new ones taught after you have learned the basic ones. An additional basic throw, the leg hock, is not described in this manual.

59

a. Speed is the primary factor in throwing an opponent in combat. In training, however, strive for precision and accuracy. Do each phase of the throws with deliberate action. Once you have thoroughly learned the throws, work for speed through constant practice.

b. In the beginning, your partner should offer no resistance. He should cooperate and permit you to execute the throw while he concentrates on assuming a good fall position.

c. The three throws described in this section may be executed from either side simply by substituting the words "right" for "left" and "left" for "right."

60. Right Hip Throw

a. Start the right hip throw from the guard position, facing your opponent. Place your left foot in front of and slightly inside of your opponent's left foot. At the same time, strike your opponent vigorously on his right shoulder with the heel of your left hand and grasp his clothing here (fig. 53 ①). This blow knocks him off balance.

b. Pivot to your left 180° on the ball of your left foot. During your pivot, place your right arm around your opponent's waist and jerk him forward forcefully with both arms, driving his midsection into your buttocks. This maneuver bends your opponent over your right hip at his waist and leaves him partially suspended in this position. At the completion of this maneuver, your buttocks are into your opponent's midsection, your right foot is in front of and slightly outside of his right foot, and your knees are bent (fig. 53 ②).

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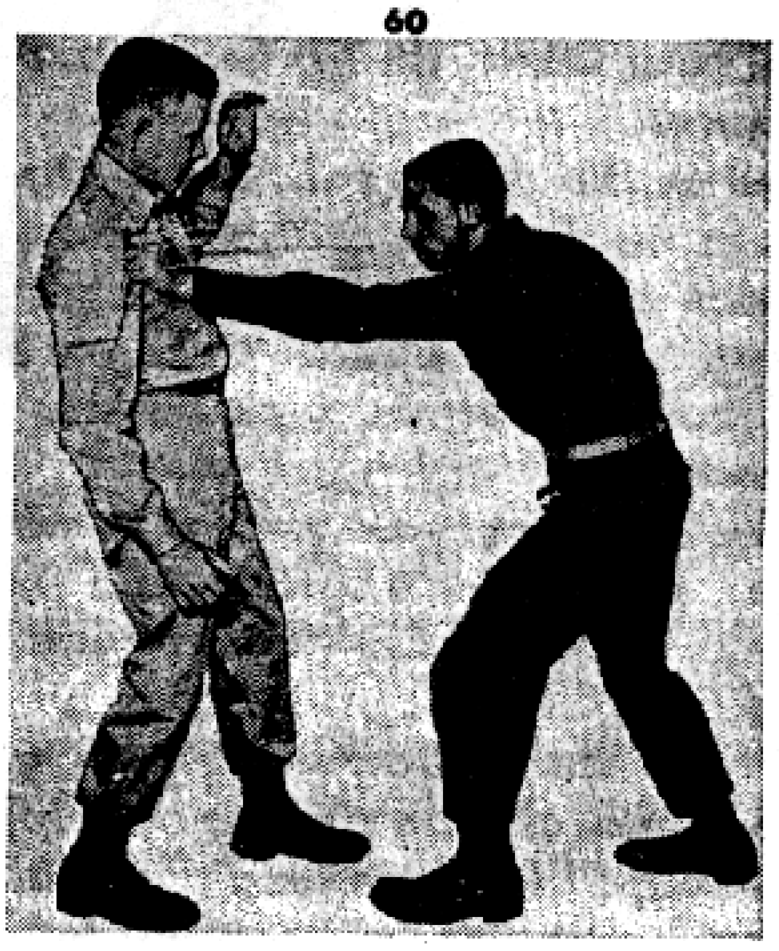
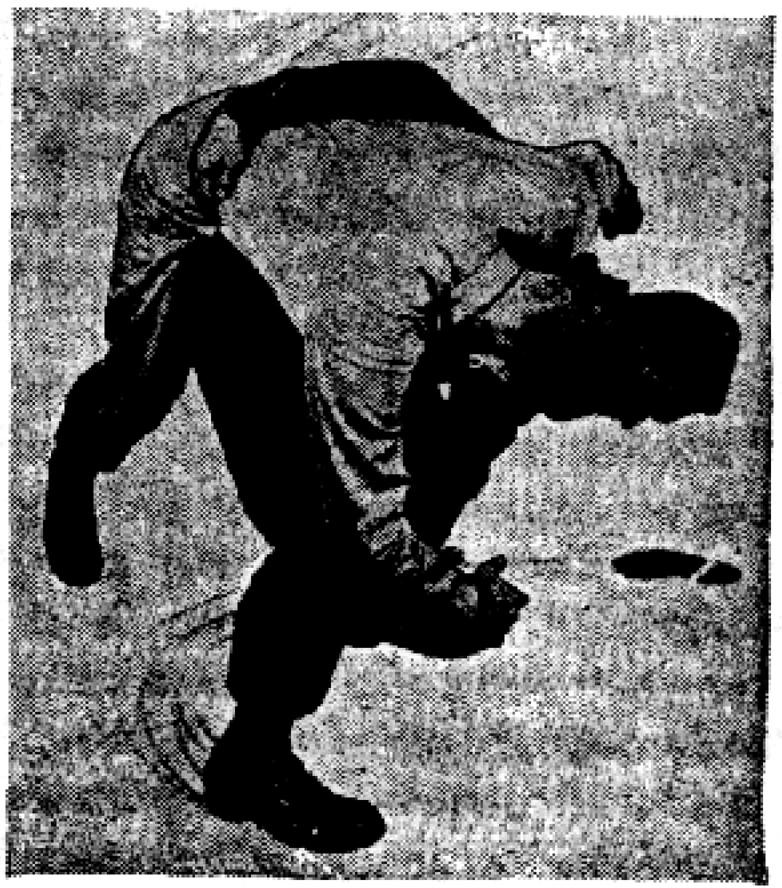


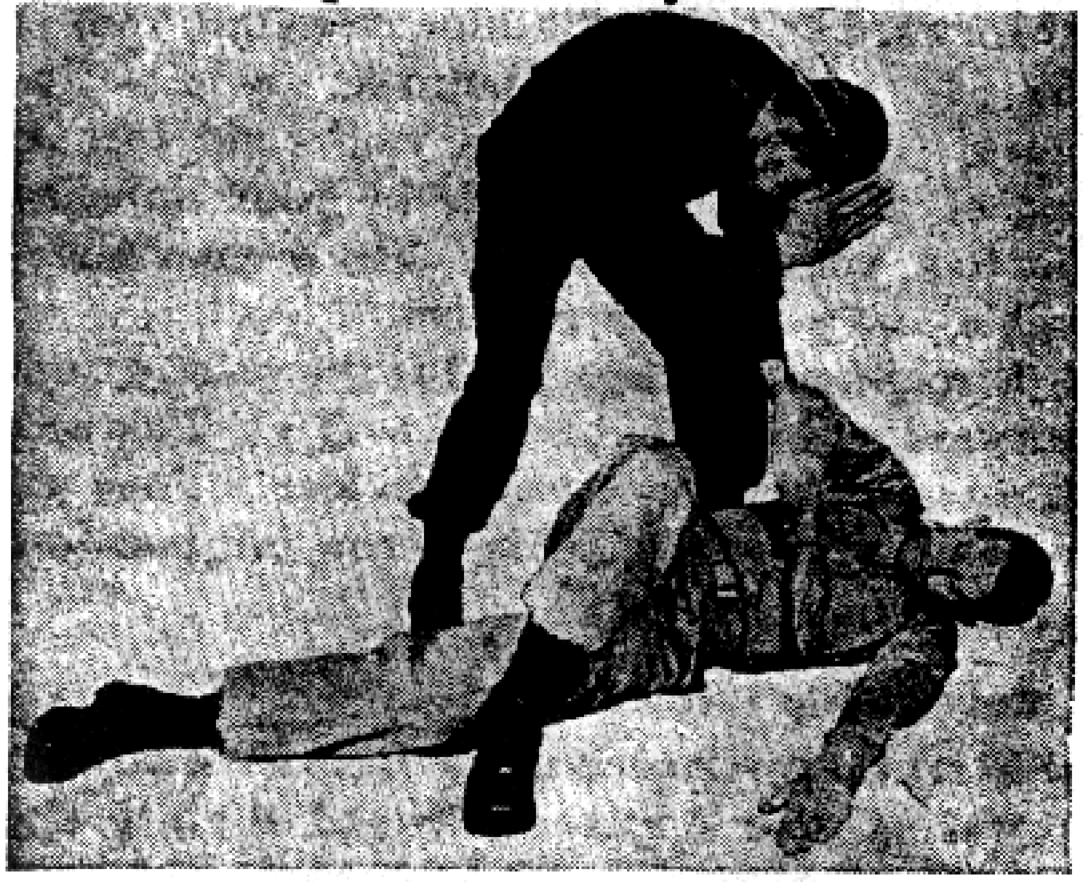
① Knock an opponent off balance by striking him forcefully on the right shoulder



② Suspend the opponent in midair by jerking forcefully forward with both arms

Figure 53. Right hip throw.

c. Straighten your legs quickly, thrusting your buttocks forcefully into your opponent's midsection. At the same time, bend forward at the waist and pull forward and down with both arms, driving your opponent to the ground (fig. 53 ③). Use your hip as a fulcrum, throwing the man over your right hip and not over the outside of your leg. At the completion of the throw, your opponent lands in the left side fall position. You are poised to deliver a blow to a vulnerable part of his body.



③ Be ready to deliver a killing blow to a vulnerable point

Figure 53. Right hip throw—Continued.

61. Over Shoulder Throw

a. Start the over shoulder throw from the guard position, facing your opponent. The first phase of this throw is identical to the first phase of the right hip throw and the foot work is identical throughout to that of the right hip throw. Place your left foot in front of and slightly inside of your opponent's left foot. At the same time, strike him vigorously on his right shoulder with the heel of your left hand and grasp his clothing here (fig. 53 ①).

b. Pivot to your left 180° on the ball of your left foot. Keep your right arm in position to protect your head and neck region until you near the completion of the pivot. Then reach up and grasp your opponent's clothing at his right shoulder with your right hand, gripping him here with a double hand hold. As you complete your pivot, pull your opponent forward and drive his midsection into your buttocks (fig. 54 ①). Your buttocks are directly in front of your opponent's hips, your right foot is in front of and slightly outside of your opponent's right foot, your elbows are as close to your body as possible, and your knees are bent.

c. Straighten your legs, bend at the waist, and pull downward with both hands (fig. 54 ②). This action will catapult him over your shoulder. Your partner assumes the over shoulder throw fall position as he strikes the ground.

62. Reverse Hip Throw

a. Start the reverse hip throw from the guard position, facing your opponent. Stand slightly closer to him than in the two previous throws. Take a long step forward with your left foot and place it slightly outside of and a few inches beyond your opponent's right foot. Most of your weight is supported on your left foot. At the same time, strike your opponent forcefully on his right upper arm with your left hand and grasp his arm at this point with that hand (fig. 55 ①). This blow causes him to lose his balance to the rear.

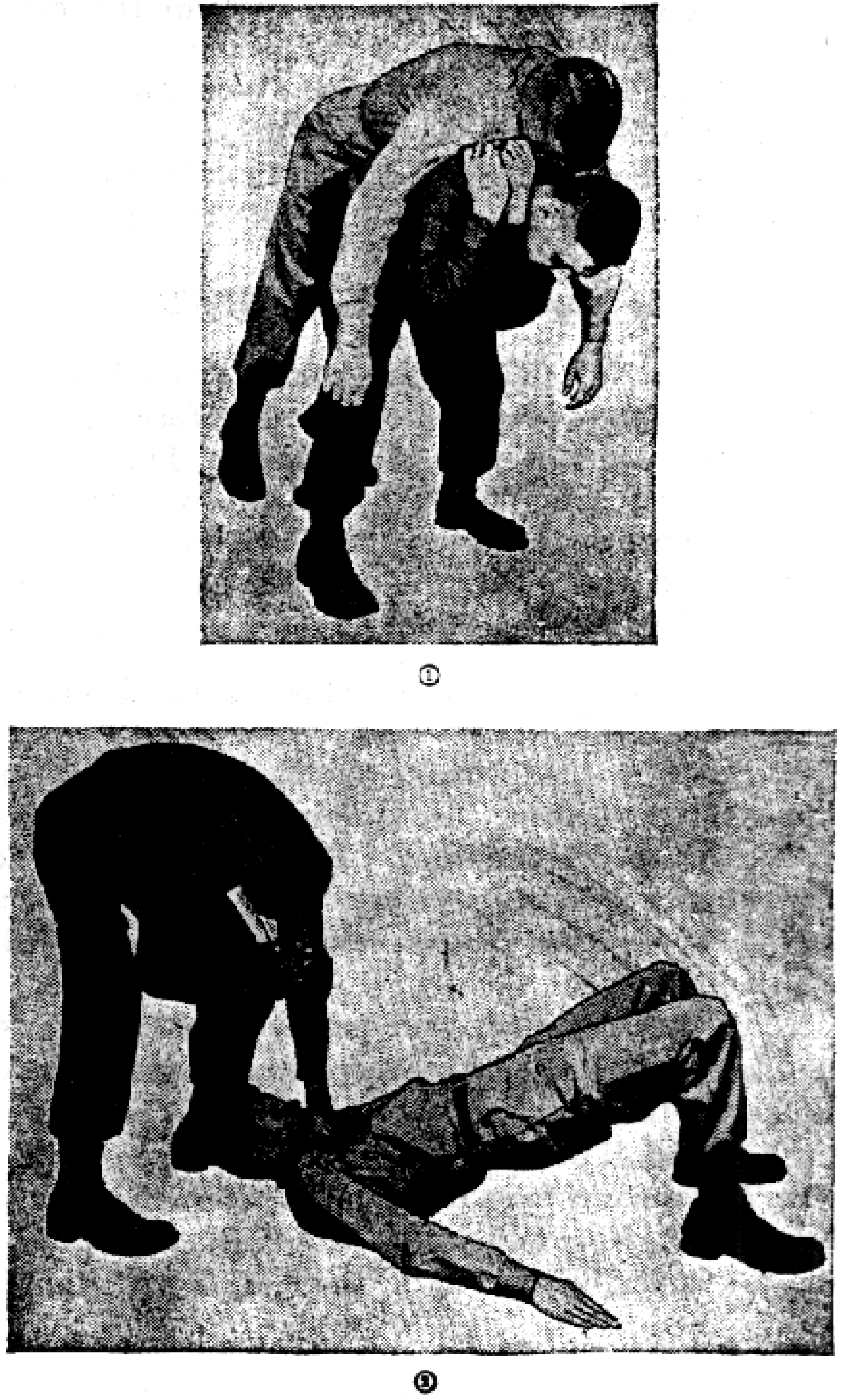


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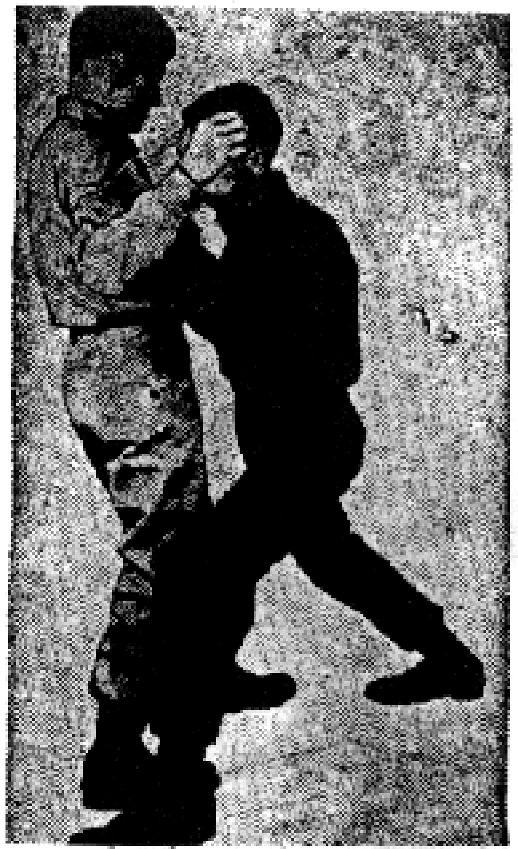
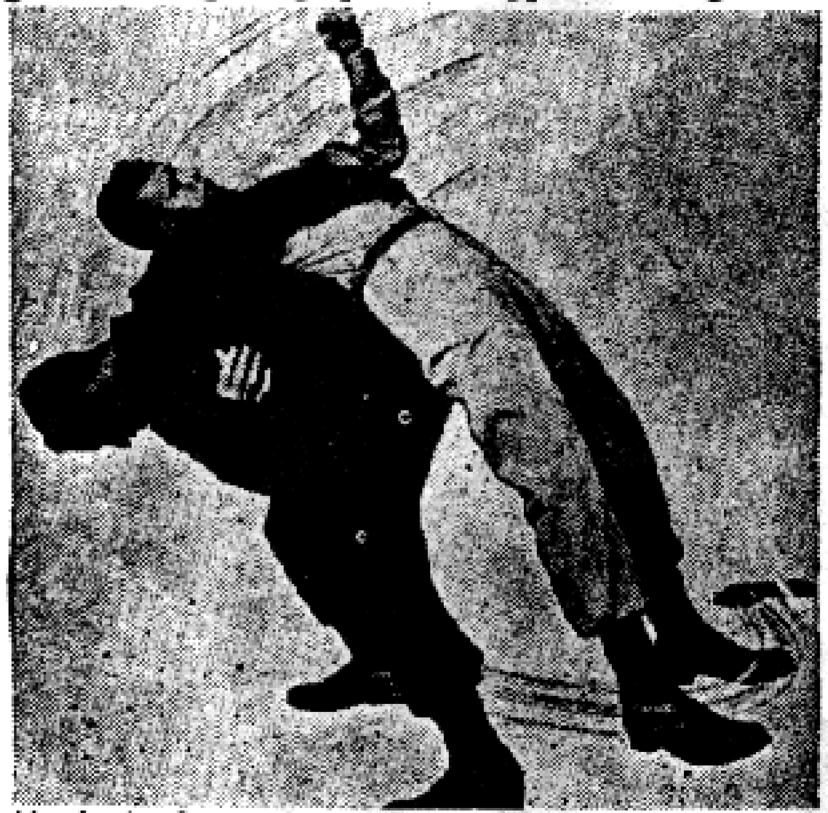
Figure 54. The over shoulder throw.

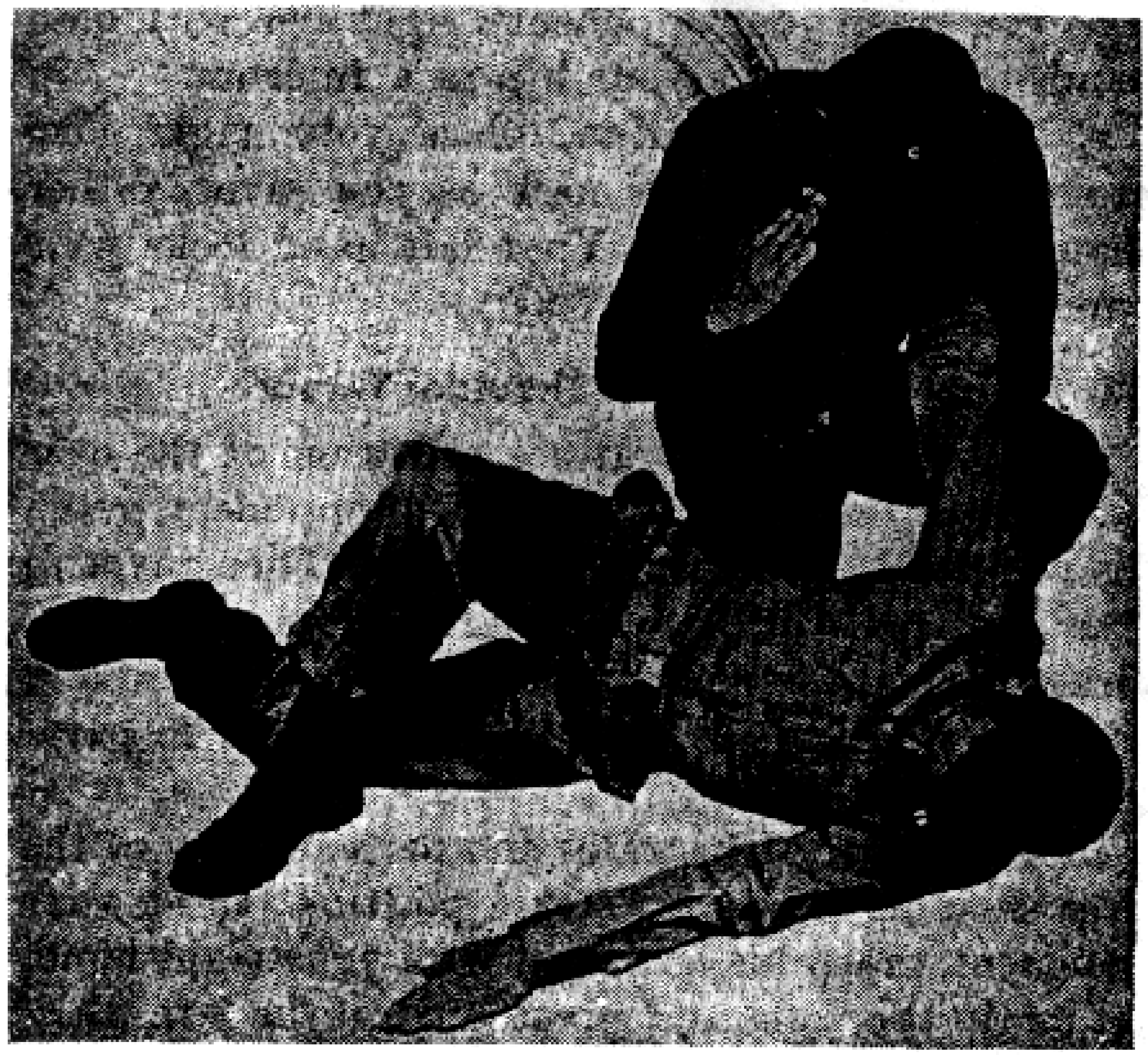


① Secure a good grip on the opponent's right arm



② Gain buttock to buttock contact and suspend the opponent in midair

Figure 55. Reverse hip throw.



③ If the fall does not knock the man out, deliver a blow to a vulnerable point

Figure 55. Reverse hip throw—Continued.

b. Step around your opponent with your right foot and place it directly behind him. At the same time, encircle his waist with your right arm. Push your hips to your right as far as possible to gain buttock to buttock contact, and pull your opponent in position on your right hip. At this time, lock your opponent's right arm into your side with your left elbow (fig. 55 ②).

c. Straighten your legs, use your right hip as a fulcrum, and slam the man to the ground (fig. 55 ③). Be sure to use your hip as a fulcrum and throw your opponent over your hip, not over the side of your right leg. Notice in figure 55 ③ that you retain the armlock on your opponent's right arm. Also notice that the man who was thrown has assumed the left side fall position.

Section IV. VARIATIONS

63. Variations of the Hip Throw

a. Figure 56 ① illustrates a variation of the left hip throw. Both of your opponent's arms are securely pinioned, his right arm with a single elbowlock and his left arm clasped at the elbow.

b. Figure 56 ② illustrates another variation. This time you grasp your opponent's right arm with both hands and again use your hip as a fulcrum.

c. In a third variation, place your right arm around your opponent's neck as you pivot, rather than around his waist. Your left hand locks your opponent's right arm (fig 56③).

64. Variations of the Over Shoulder Throw

a. Figure 57① illustrates a variation of the over shoulder throw. While facing your opponent, grasp his right wrist with your left hand. Then pivot to your left 180°, pulling him forward as you do so. Grasp his right upper arm with your right hand and throw him over your shoulder as described in paragraph 61.

b. Figure 57② illustrates another variation of the over shoulder throw. From a position facing your opponent, grasp his left lapel with your right hand. Maintain this hold and pivot 180° to the left, placing your right forearm under his right armpit as you complete the pivot. Grasp his right arm at the elbow as you execute your pivot.

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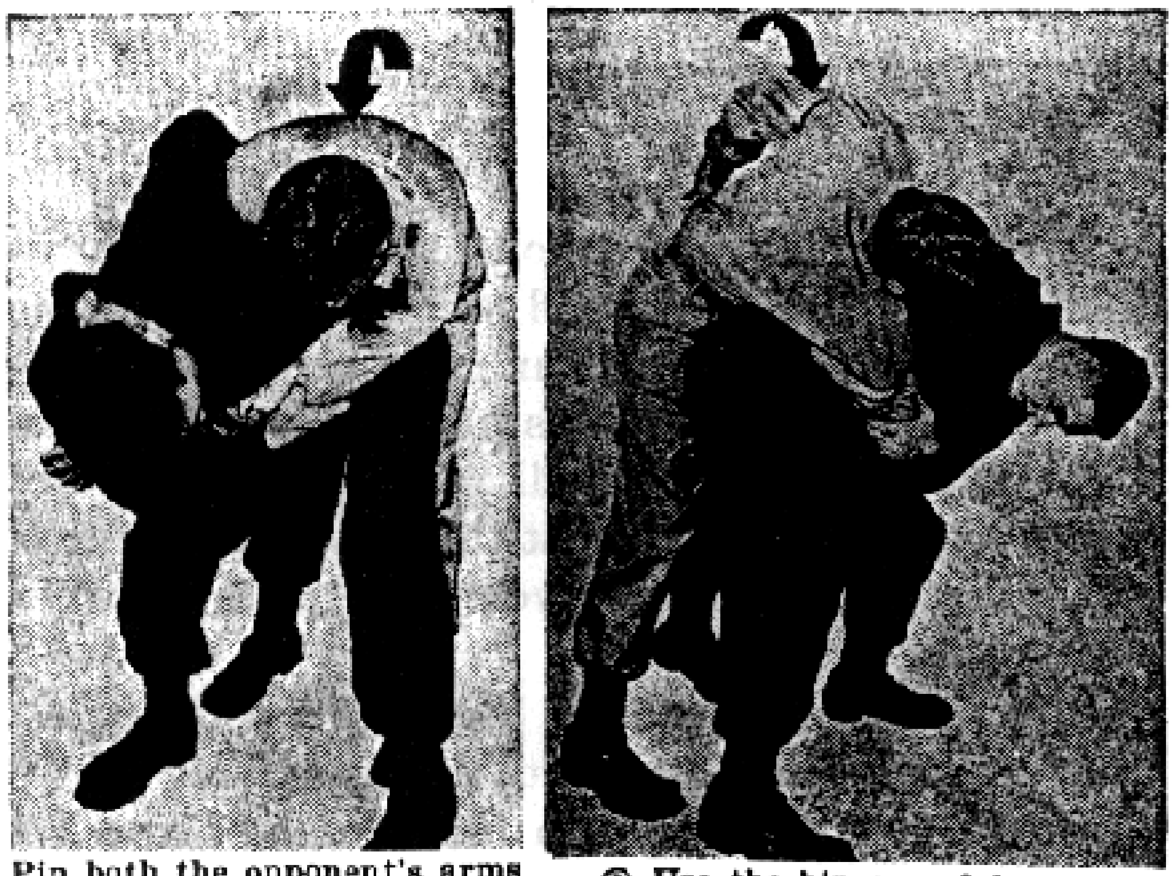

① Pin both the opponent's arms ② Use the hip as a fulcrum

Figure 56. Variations of the hip throw.

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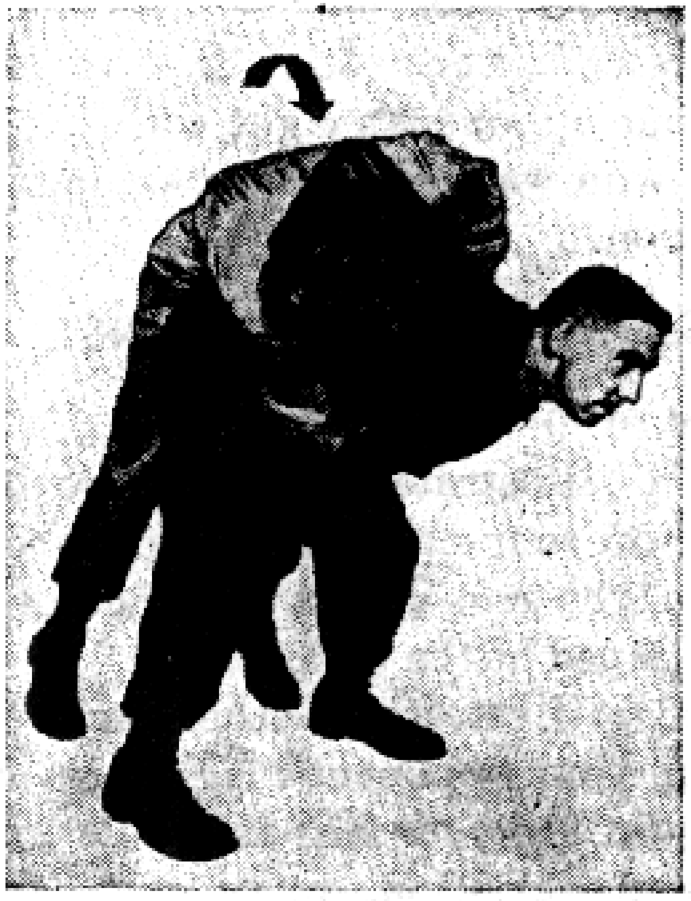
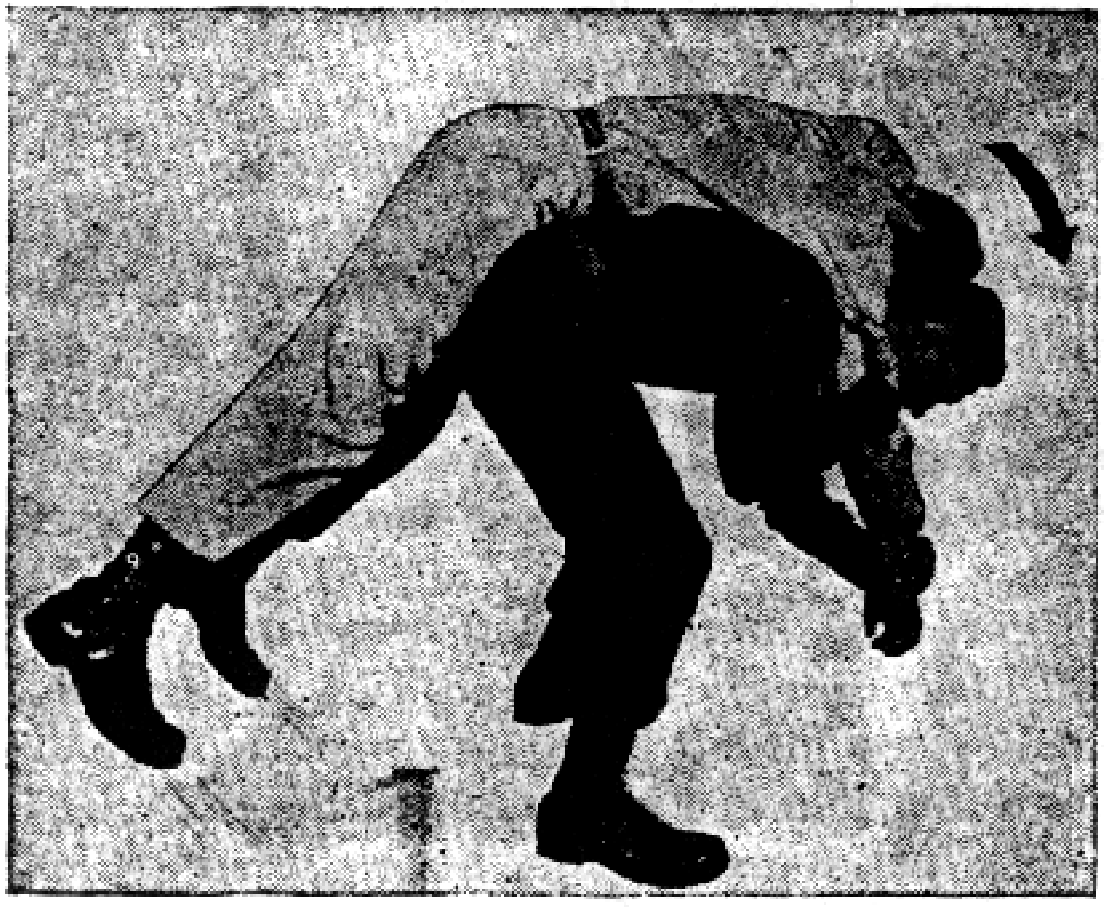


③ Grasp the opponent around his neck

Figure 56. Variations of the hip throw—Continued.



① Use the opponent's arm for leverage

Figure 57. Variations of the over shoulder throw.

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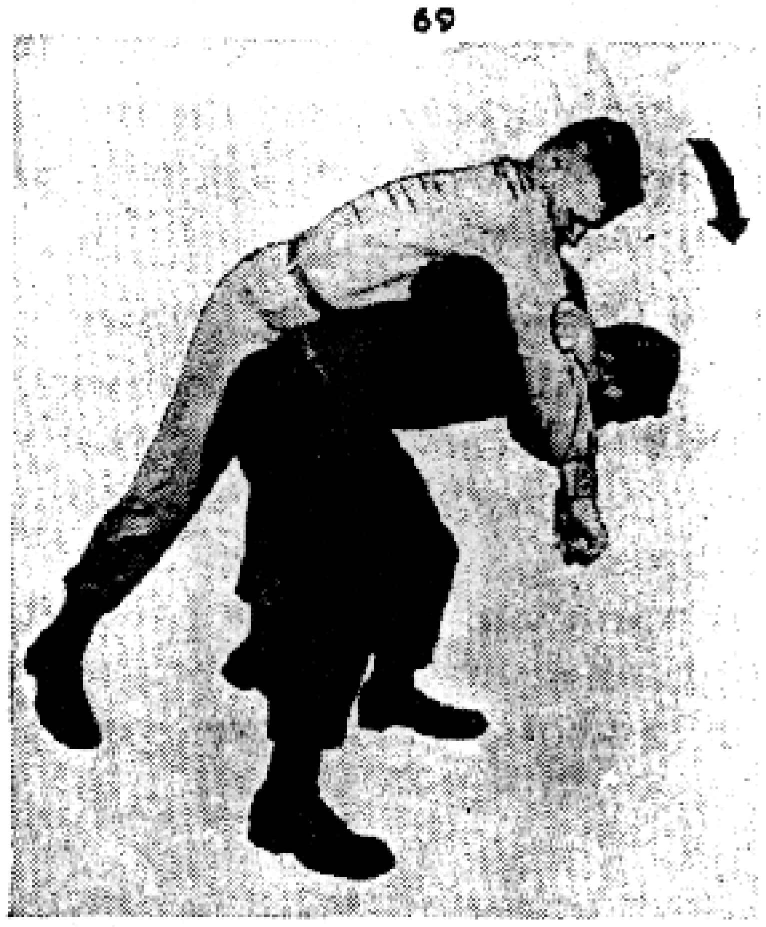
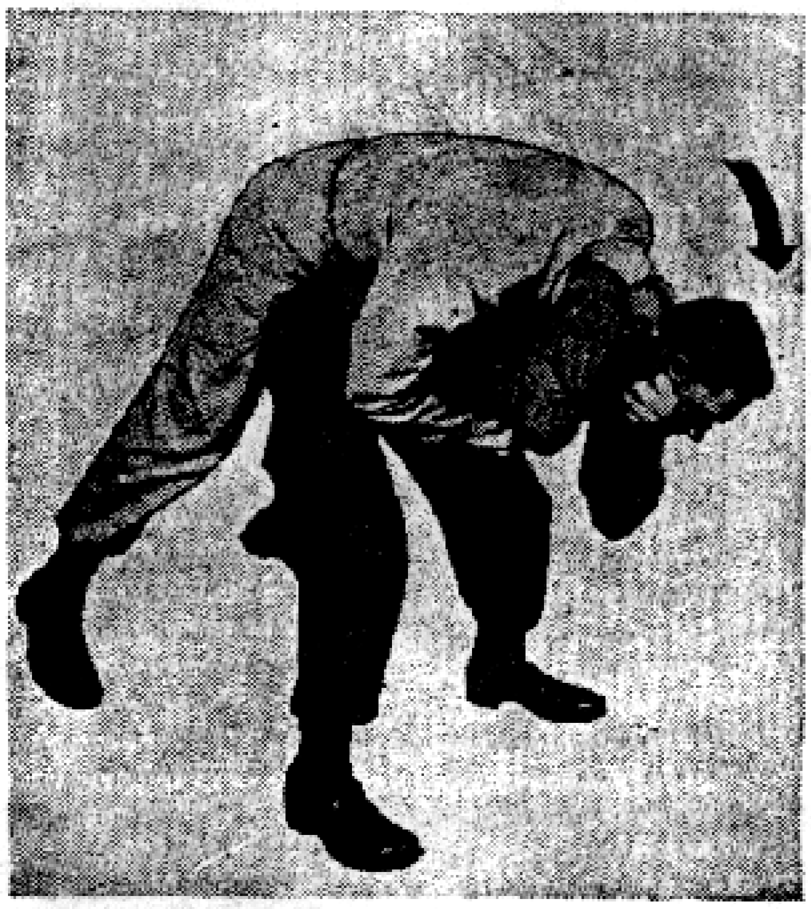


② Grasp the opponent by his lapel



③ Grasp the opponent by his hair

Figure 57. *Variations of the over shoulder throw*—Continued.

70

c. Figure 57 ③ illustrates another variation. When your opponent attacks you from the rear, grasp his hair or lock both arms around his head and throw him over your shoulder.

65. Variations of the Reverse Hip Throw

a. Figure 58① illustrates a variation of the reverse hip throw. Instead of placing your right arm around your opponent's waist, get a strangle hold around his throat.

b. In this variation, grasp the hand of the arm which you placed around your opponent's throat as described in *a* above. This gives you a strangle hold (fig. 58②).

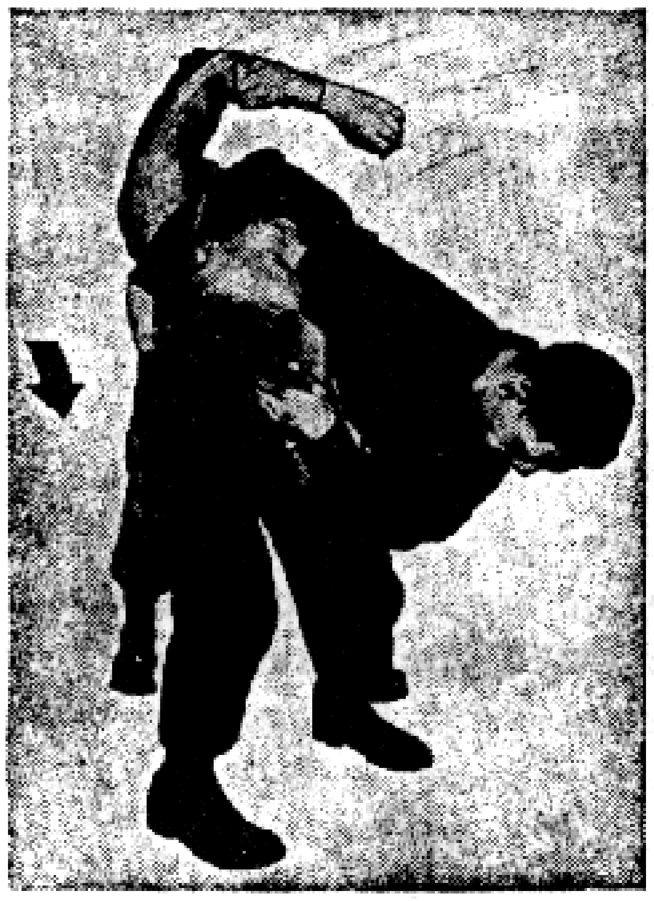


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Figure 58. Variation of the reverse hip throw.

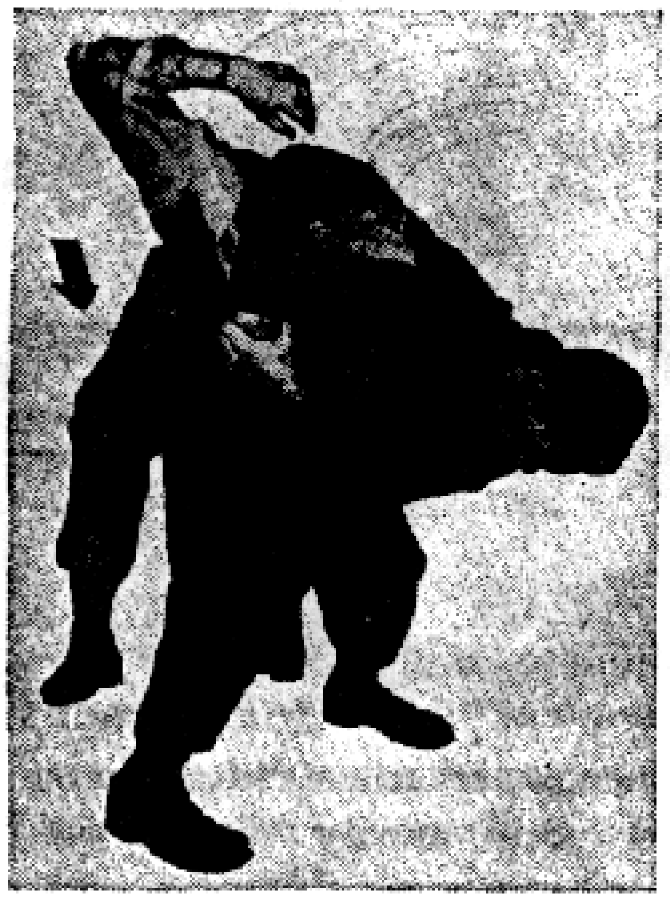

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Figure 58. Variation of the reverse hip throw—Continued.

CHAPTER 7

HOLDS AND ESCAPES

Section I. HOLDS

66. General

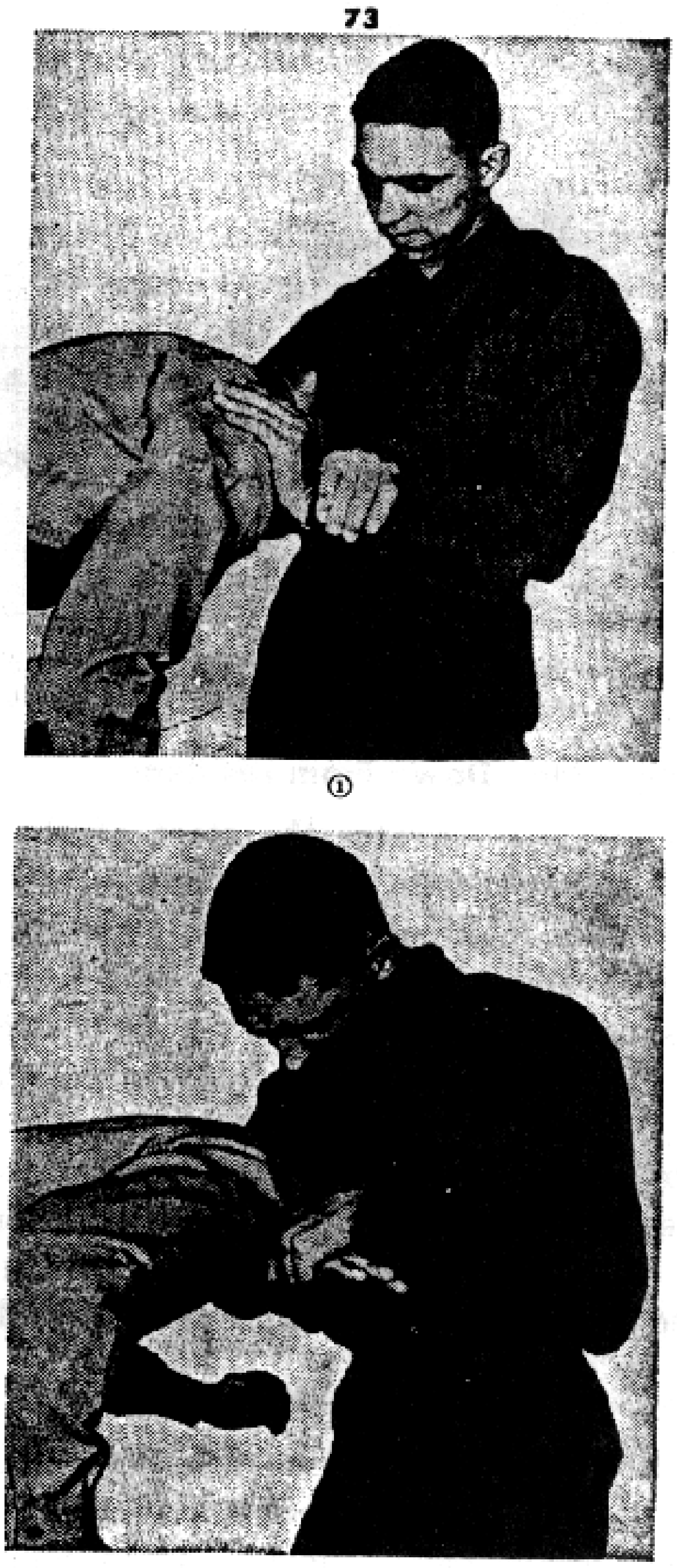
The two purposes of a hold are—

a. To kill your opponent immediately by applying enough pressure to certain parts of the body.

b. To hold your enemy until you can follow through with a blow to a vulnerable part of the body.

67. Front Strangle Hold

The front strangle hold is particularly good against a low frontal attack. As your opponent charges, slap your left hand against his right shoulder to slow his momentum and slip your right forearm under his throat. Clamp his head under your arm. Clasp your left wrist with your right hand. Apply pressure by leaning backward and lifting with your right forearm (fig. 59 ①). You can choke your opponent to death in this position. Another way to execute this hold and one which acts more swiftly is illustrated in figure 59 ②. Grasp the knife edge of your right hand with the fingers of your left, pull forcefully toward your chest and, at the same time, lean backward. Properly executed, any strangle hold can cause unconsciousness in approximately seven seconds. Continued pressure will kill a man in less than 1 minute. *When applying this hold, keep the*



①

②

Figure 59. The front strangle hold is particularly good against a low frontal attack.

74

bony, inside edge of your forearm across your opponent's Adam's apple for maximum effectiveness.

68. Side Collar Strangle Hold

Grip your opponent well back on his collar with both hands, palms down. Use the back of his collar for leverage and roll the second knuckles of your forefingers into the carotid arteries at the sides of his neck. Place both your thumbs below his Adam's apple, applying continuous pressure inward and upward (fig. 60). This hold is best used when your opponent is on the ground and unable to attack your groin. It causes unconsciousness and eventual death by stopping the flow of blood to the brain.

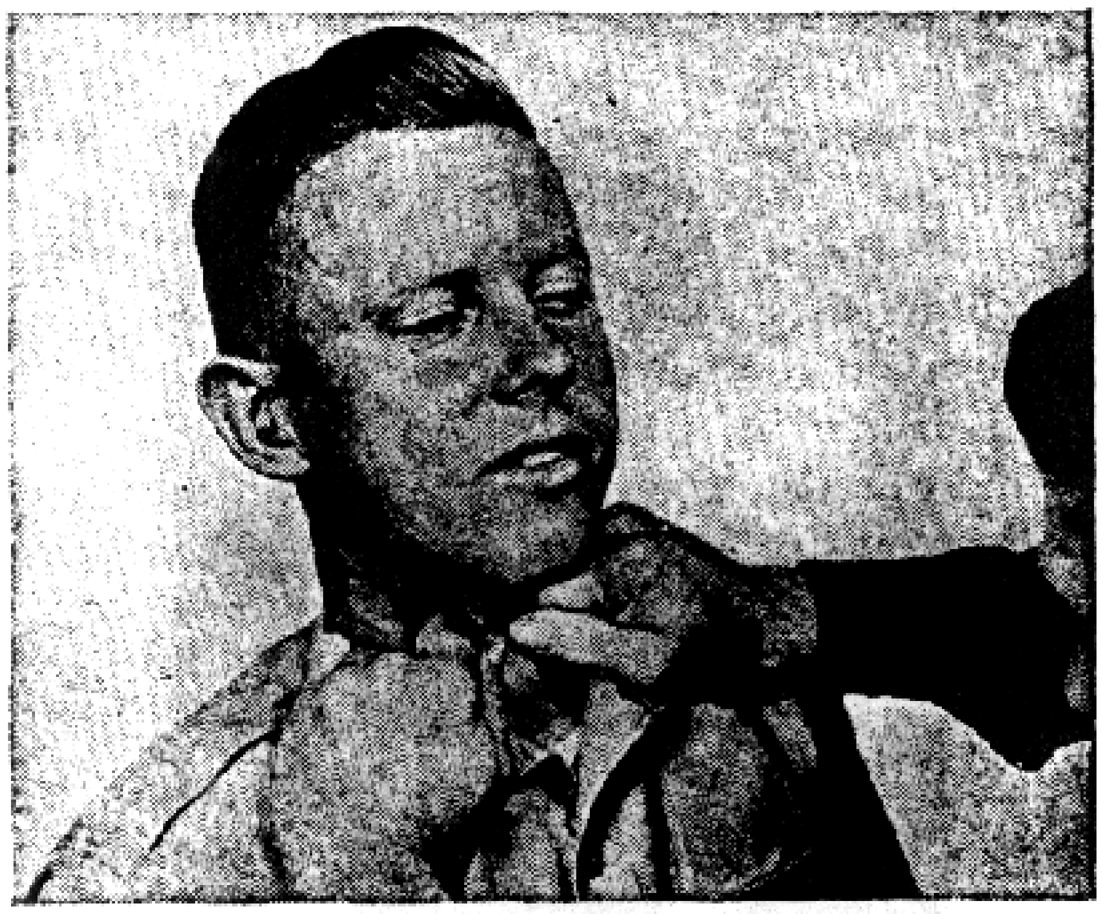


Figure 60. The side collar strangle hold stops the flow of blood to the brain and causes eventual death.

75

69. Taking a Man Down From His Rear

Figure 61 ① illustrates the start of the proper method of taking a man down from his rear. Your hands and foot make contact with your opponent's body simultaneously. Clap your hands down on his shoulders and, at the same time, pull backward. Kick the sole of the right foot forcefully against the back of your victim's knee joint (fig. 61 ②). This attack drops your victim to the ground instantly and places him in a position to be disabled or killed quickly. To knock your enemy unconscious, drive your knee to the base of his skull as he goes down.

70. Cross Collar Strangle Hold

To be effective, this hold must be executed on an individual who is wearing an open collar or who has open lapels on his coat or jacket. Cross your hands at the wrist and grasp the collar opening with your fingers on the inside and your thumbs on the outside. Pull strongly with your fingers and scissor your arm against your opponent's throat (fig. 62). He will drop to the ground unconscious. This strangle hold can also be executed from the rear. Cross your arms in front of your opponent's throat, seize his clothing at the neck, and press your arms into his throat by pulling tight.

71. Full Nelson

Execute this hold on your enemy from the rear. Place both your arms well up into your opponent's armpits and place your hands on the back of his head. Interlock your fingers (fig. 63 ①). Apply downward pressure on his head and upward pressure under his arms (fig. 63 ②).

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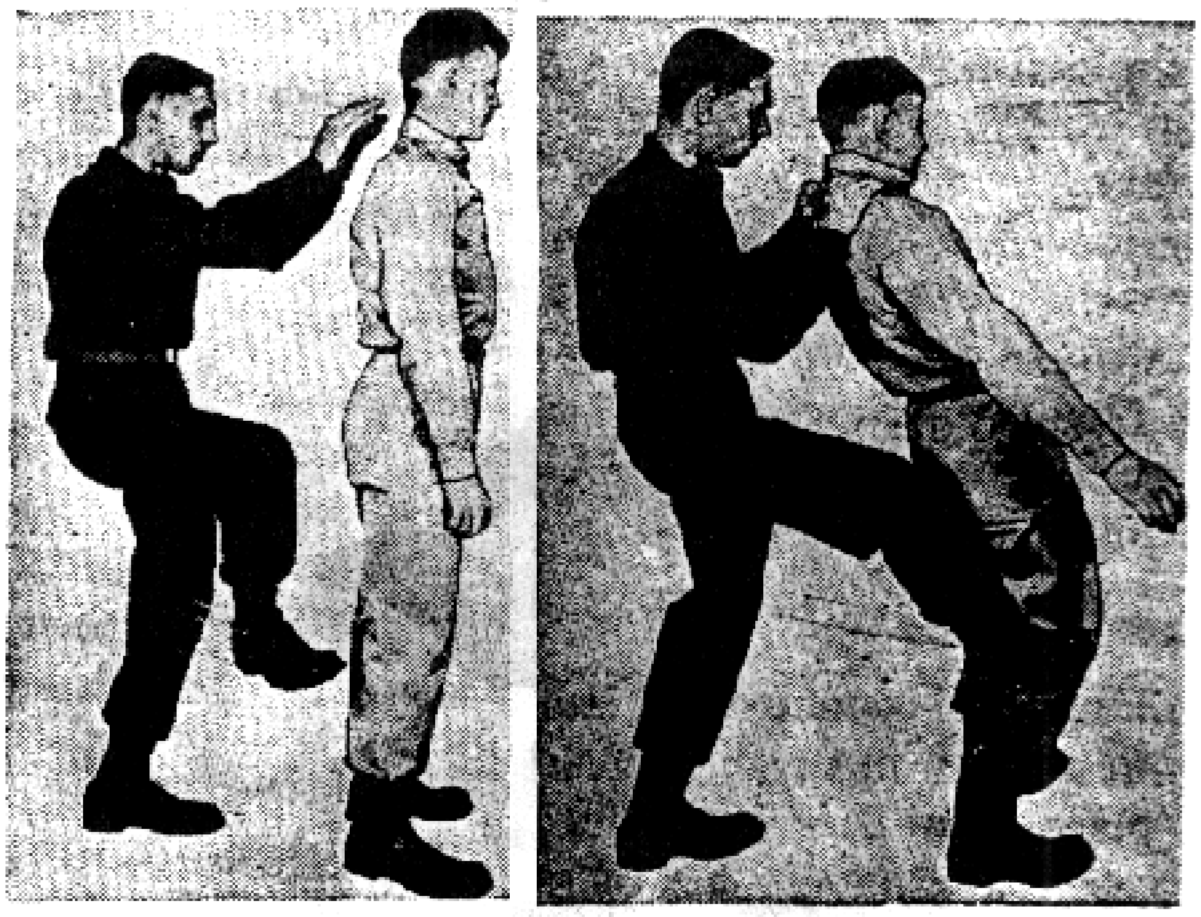

① ②

Figure 61. If an opponent has his back turned, he can easily be thrown to the ground and killed quickly.

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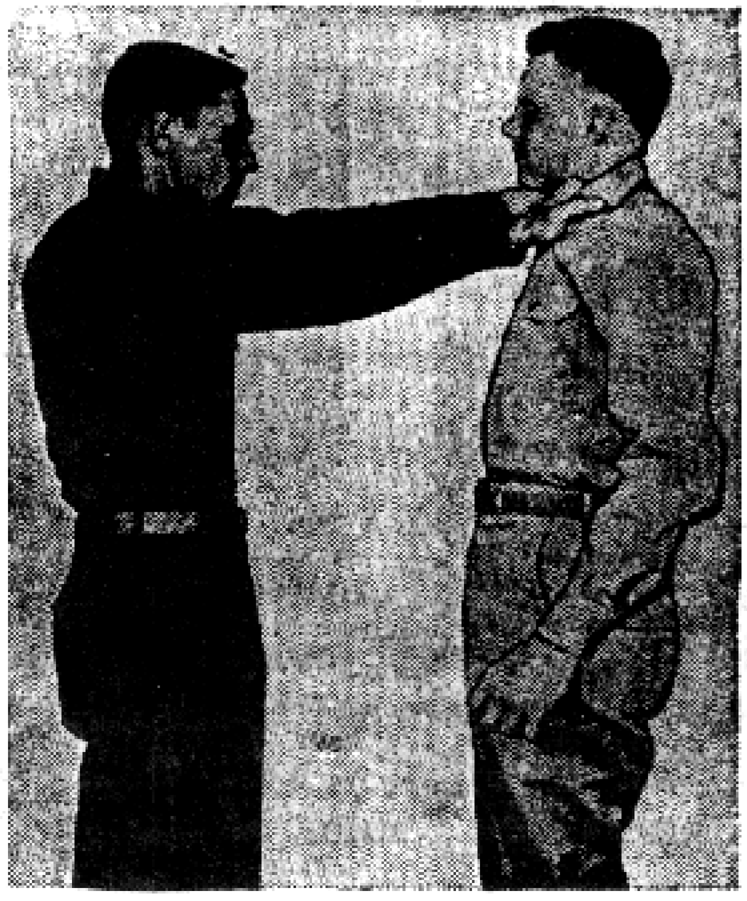

Figure 62. The cross collar strangle hold, executed properly, causes unconsciousness.

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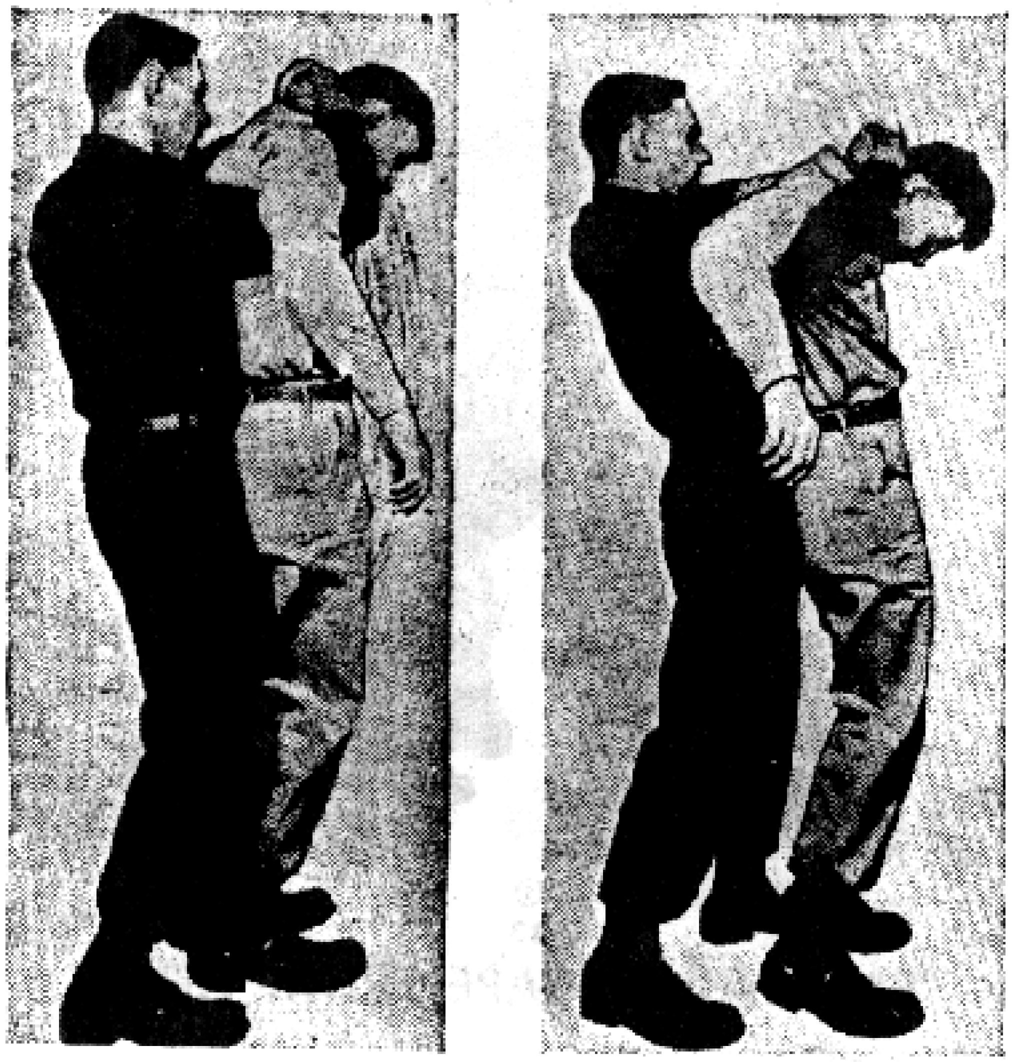

① ②

Figure 63. The full nelson is executed when an opponent has his back turned.

72. Hammerlock

To execute this hold from the rear, grasp your opponent's hand or wrist and pull backward. Then, force his forearm up toward his head (fig. 64). By keeping your right hand at his right elbow and by continuing to force up on his arm, you can easily dislocate his shoulder. To execute a hammerlock when facing your opponent, grasp his right wrist with both hands. Pivot to your left 180°. During your pivot, raise your opponent's arm above your head and step beneath it and behind him at the completion of your turn.

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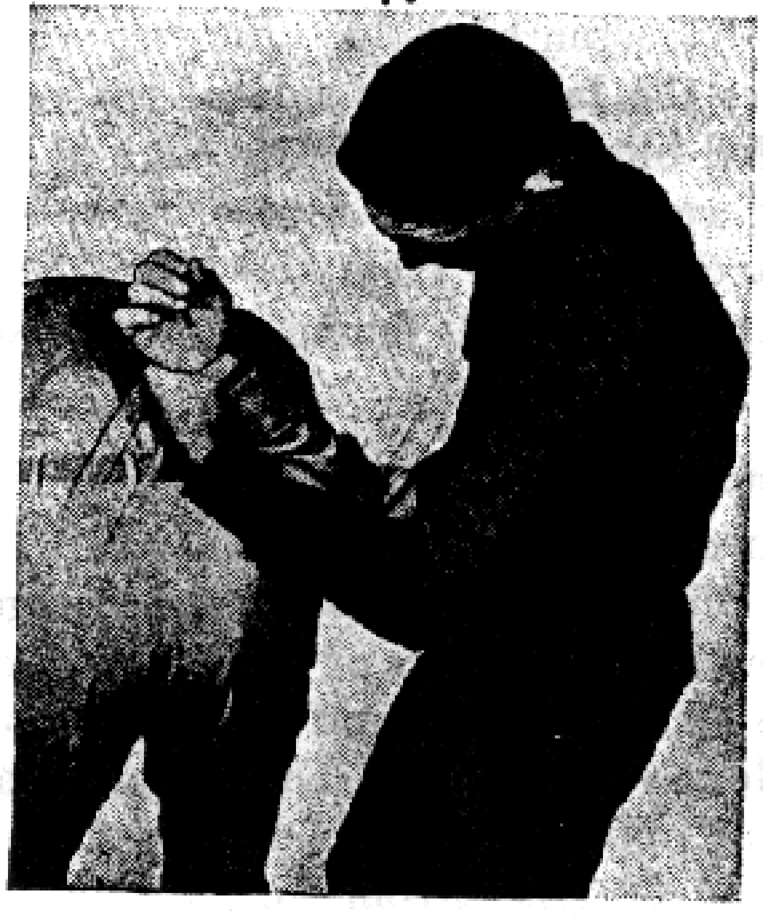

Figure 64. An opponent's shoulder can easily be dislocated by using the hammerlock.

73. Locked Rear Strangle Hold

Use the locked rear strangle hold when approaching your opponent from his rear. Place your left hand on the back of his head and, at the same time, cross your right forearm under his neck from the right (fig. 65 ①). Bring your right forearm to the left and lock it to your left upper arm (fig. 65 ②). In this position, push with your hand on the back of his head and lean forward. Enough pressure can break his neck. *Keep the inside, bony edge of the right forearm over your opponent's Adam's apple for best effect.*

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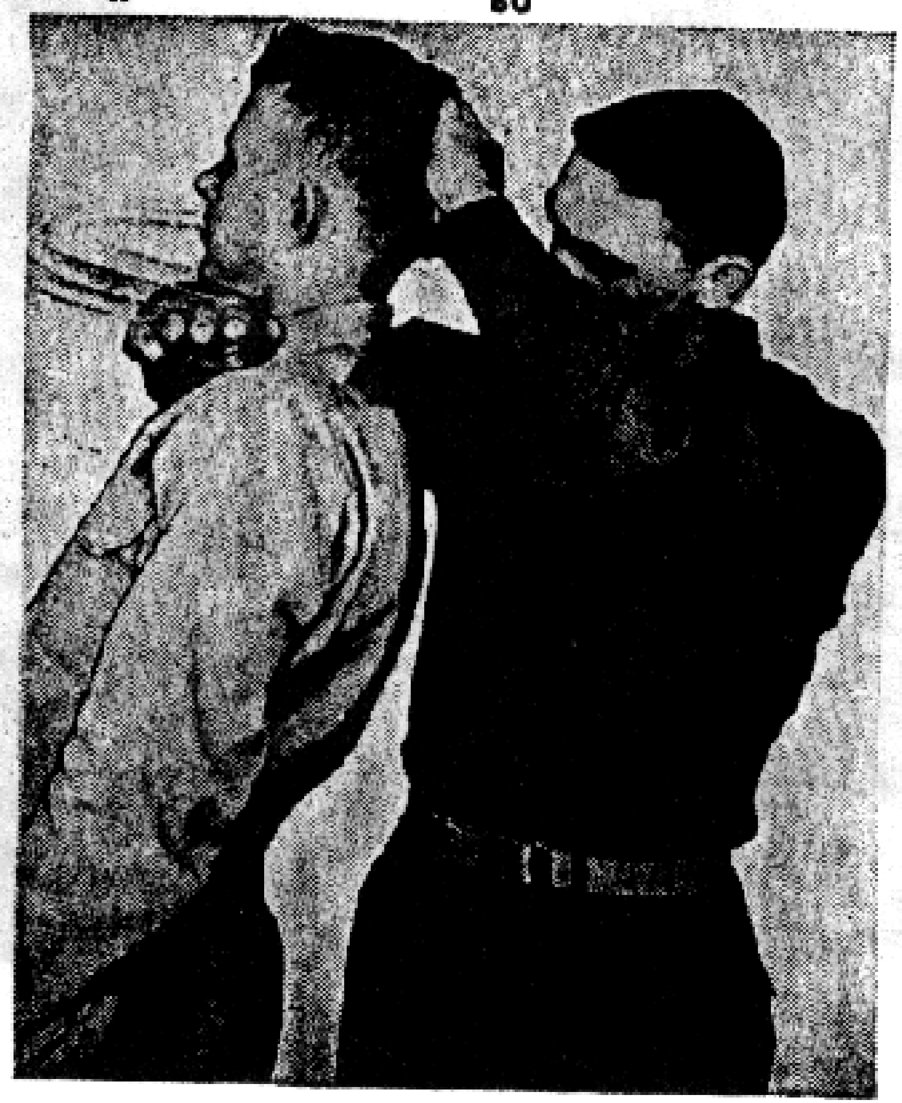

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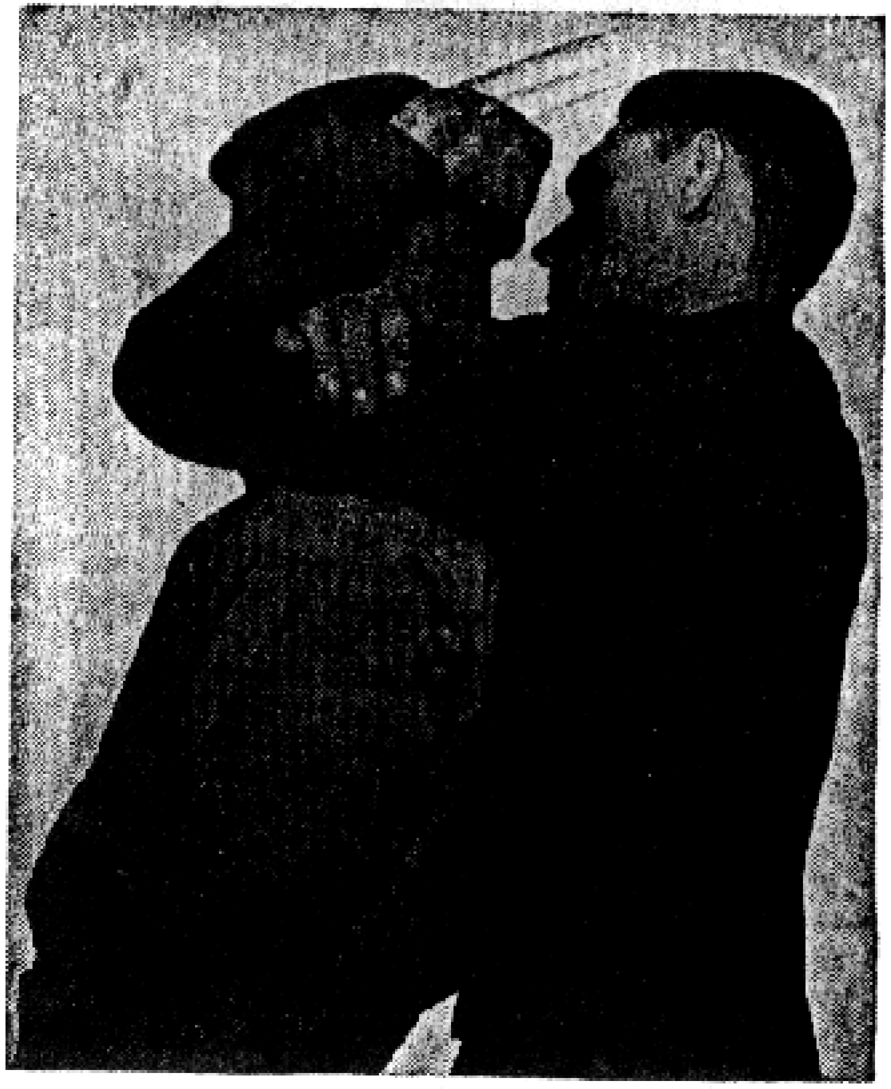
Figure 65. The locked rear strangle hold can break an opponent's neck.



②

74. Double Wristlock

To execute a double wristlock, grasp your opponent's right wrist with your left hand (fig. 66 ①). Pass your right hand and arm over his right upper arm, under his bent elbow, and clasp your left wrist, completing the double wristlock (fig. 66 ②). Continue the movement by jerking his arm up and back into a twisting hammerlock (fig. 66 ③). Figure 66 ④ illustrates a variation of the double wristlock.

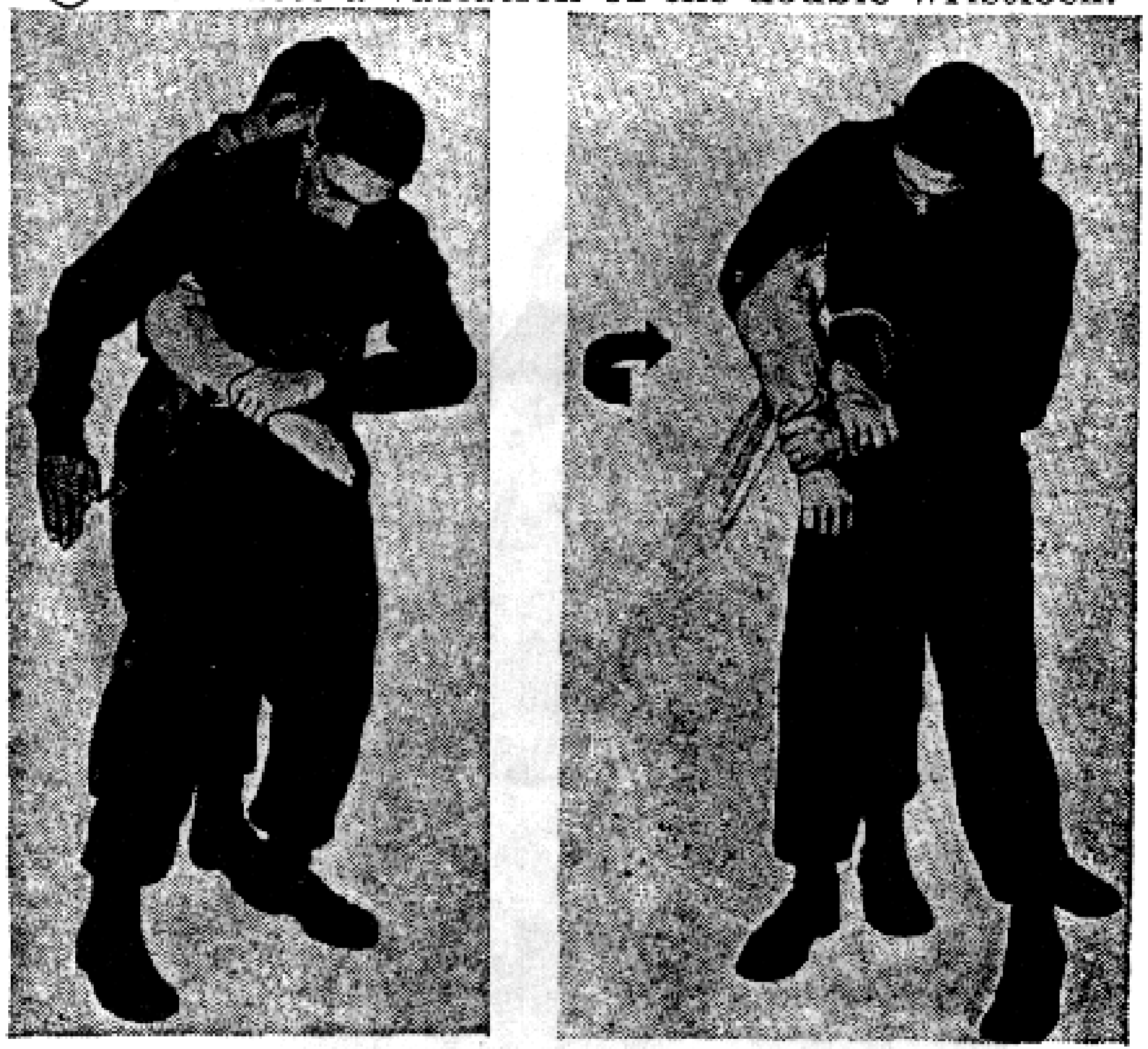

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Figure 66. The double wristlock may be continued into a hammerlock.

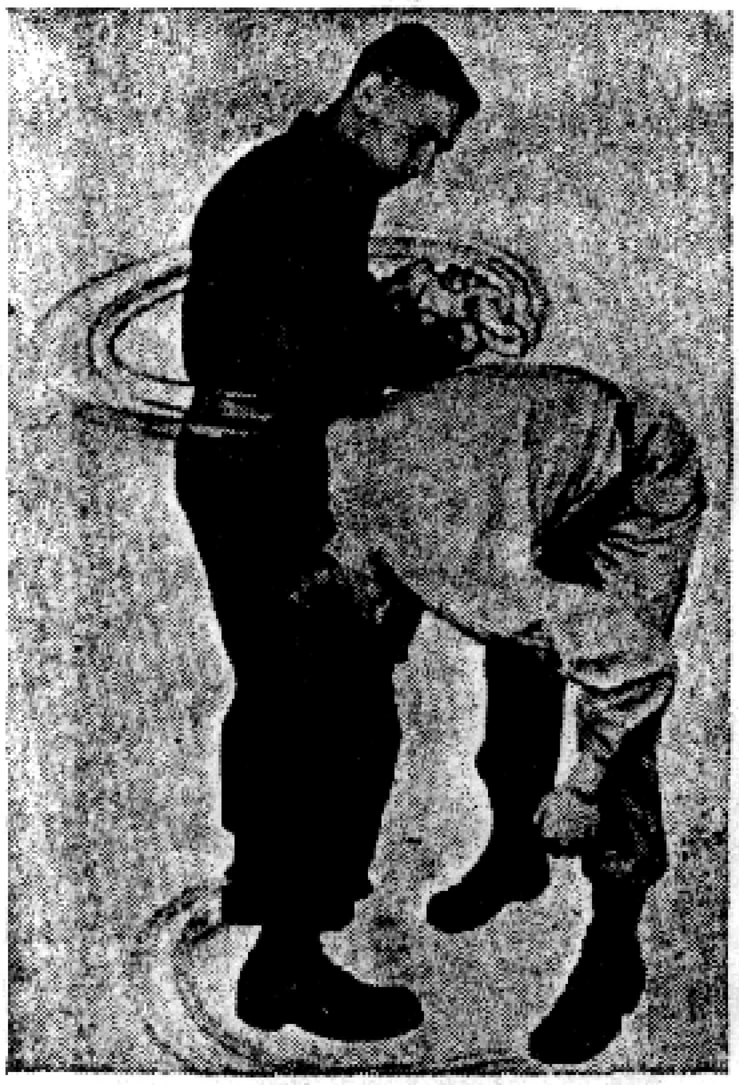
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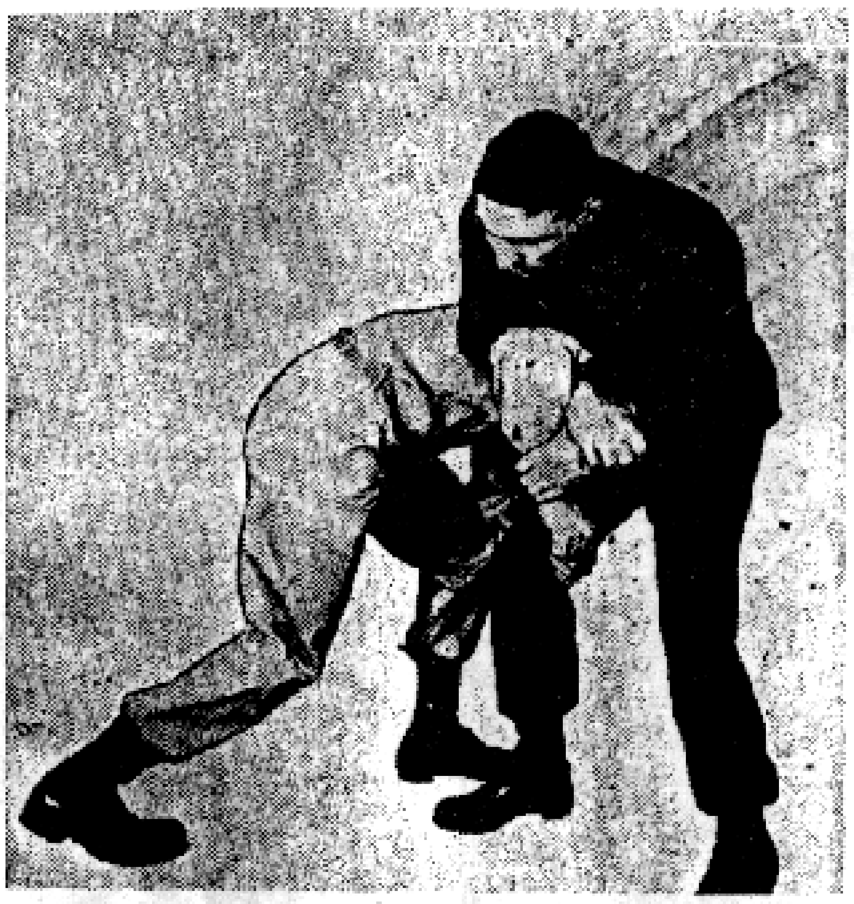
Figure 66. The double wristlock may be continued into a hammerlock—Continued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Section II. ESCAPE FROM HOLDS

75. General

If your opponent succeeds in getting a hold on you, you must break this hold before or immediately after he completes it. Bite, kick, or strike him at vulnerable points to help loosen or break the hold before he can apply pressure. By escaping from your opponent's grasp immediately, you can take the offensive again and attack him.

76. Escape From Choke Hold

When your opponent attempts to choke you (fig. 67 ①), use the arm swing tc break his hold. Swing your arm over his arms in a forceful roundhouse blow. As you do this, pivot in the direction of your swing to get as much of your body weight behind your arm as possible (fig. 67 ②). This causes your opponent to loosen his hold. Be prepared to strike him across the face or the side of the neck with a backhanded blow with the knife edge of your hand before he recovers. This escape can also be used against a choke hold from the rear. Swing your arm and pivot around, facing your attacker as you swing.

77. Second Escape From Choke Hold

As your opponent gains the hold, clasp your hands together (fig. 68 ①). Grip the knife edge of your left hand with the fingers of your right, and tightly wrap the left thumb around the right thumb. Do not interlock your fingers. Drive your hands up between your opponent's arms, forcing him to loosen his hold (fig. 68 ②). From this position, smash your clasped hands on the bridge of his nose (fig. 68 ③), or grasp the back of his head and pull it down, meet-

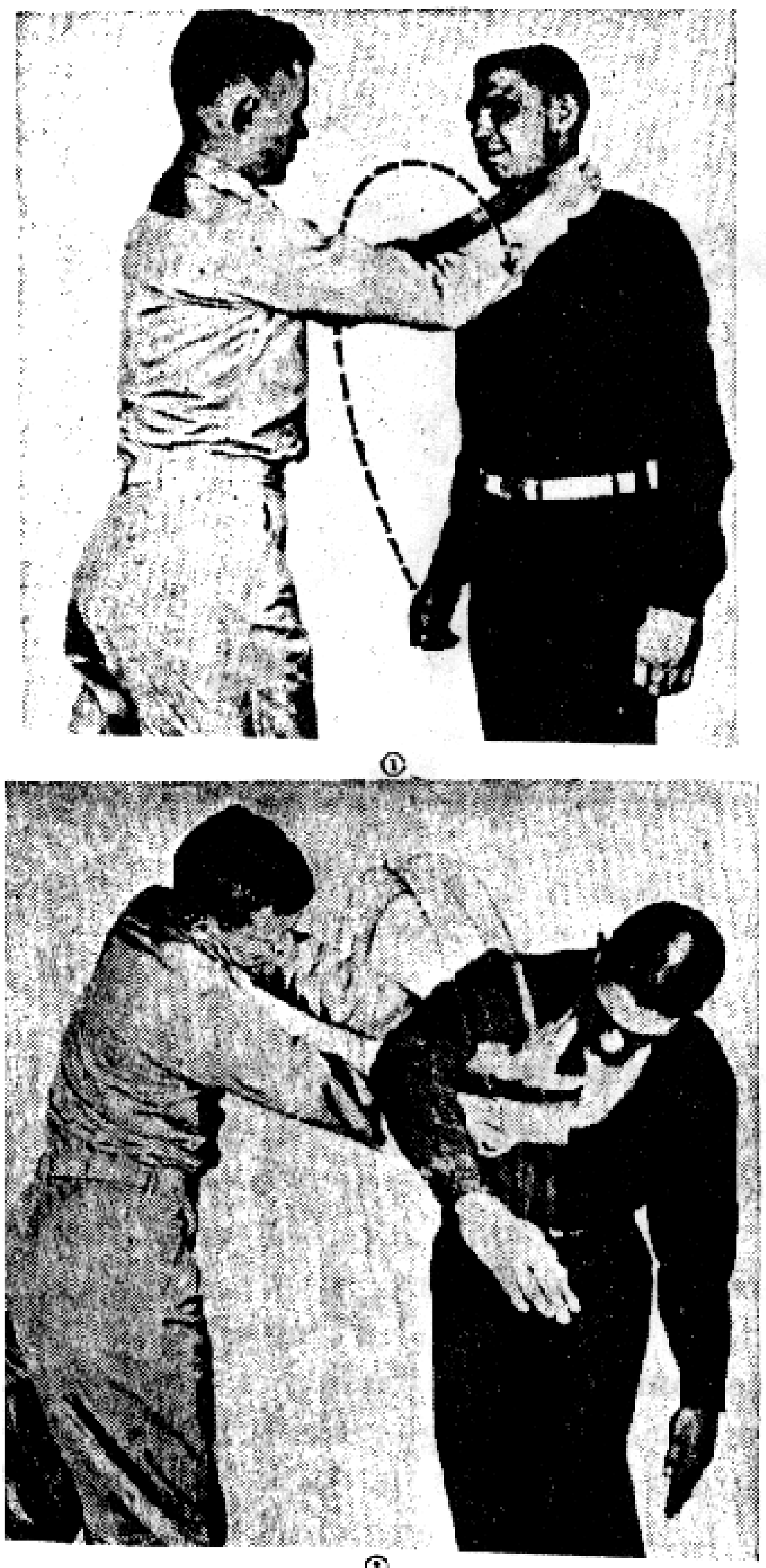
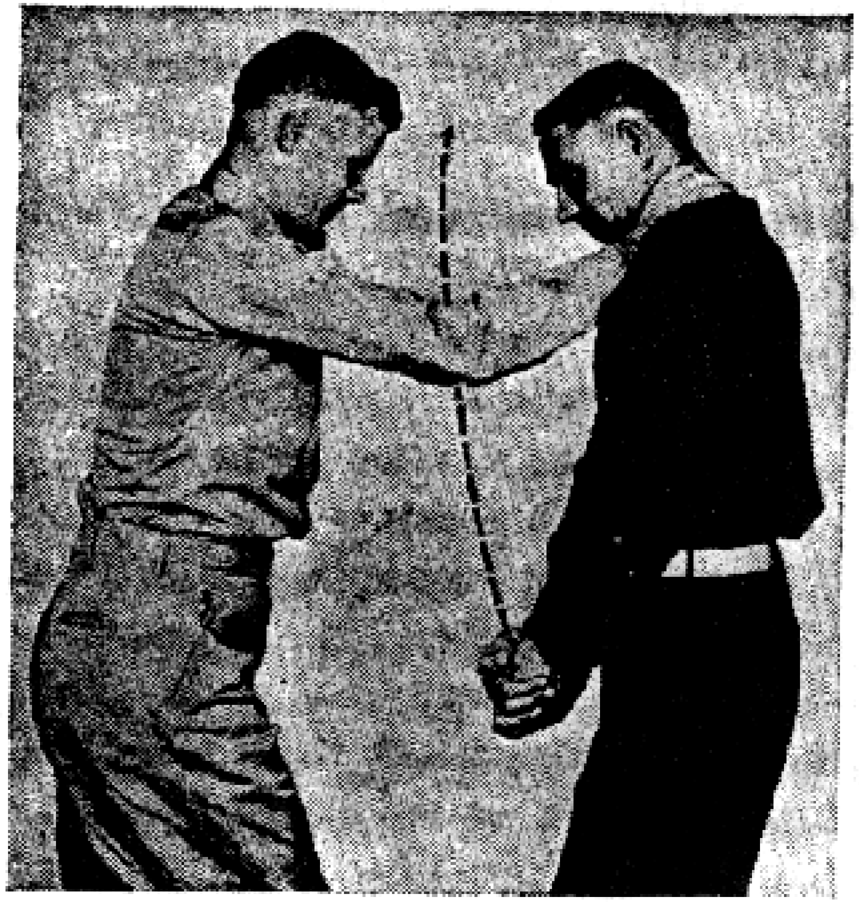


Figure 67. The choke hold is broken by a roundhouse arm swing.



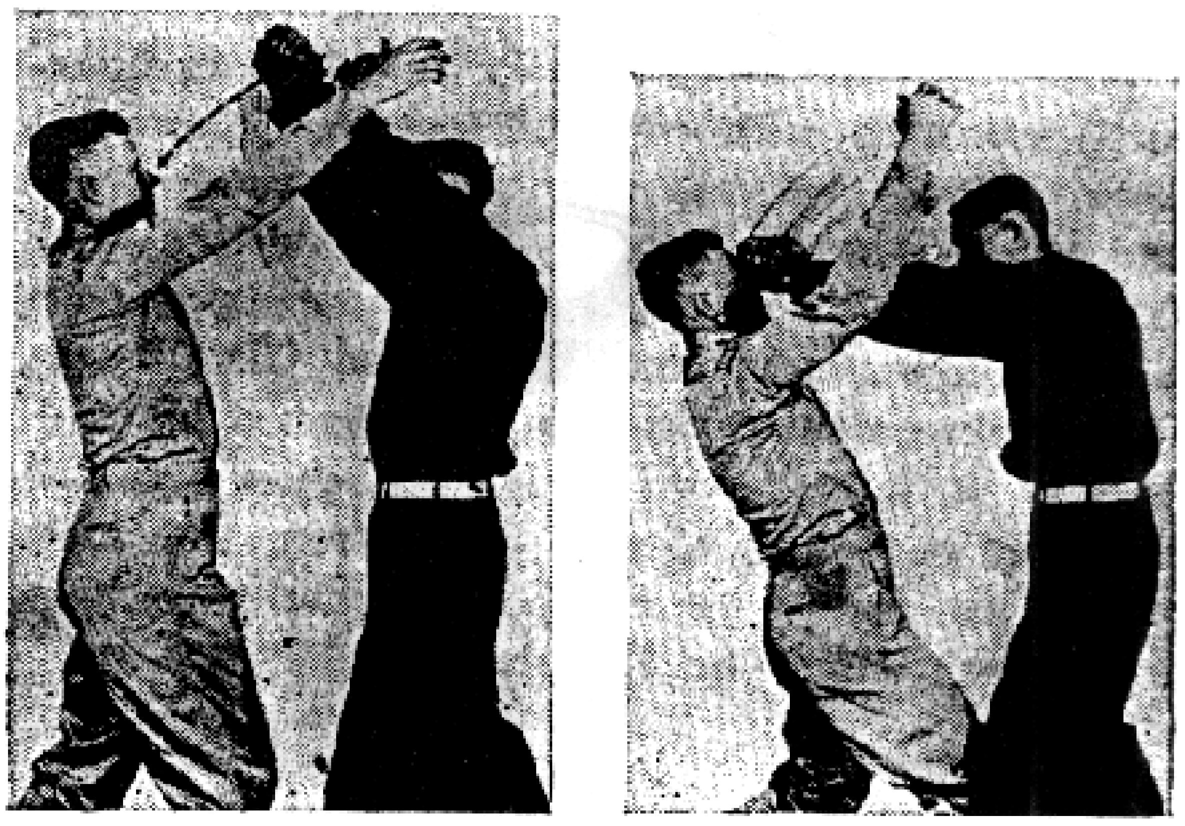


Figure 68. The choke hold can be broken and an opponent injured in one continuous motion.

ing it with a knee-lift. You can also separate your hands after breaking the hold and strike his collar bone with the knife edges of your hands.

78. Escape From Two-Hand Strangle Hold When Pinned Against Wall

Ordinarily, an opponent attempting to strangle you while your back is to a wall extends his arms, squeezes with his fingers, and pushes you against the wall (fig. 69 ①). To escape from this hold, place the heel of your right hand on his left elbow and the heel of your left hand on his right elbow. Apply pressure inward and away from you (fig. 69 ②). This prevents your opponent from using the power of his fingers and he cannot choke you. To drive him back, drive your knee or toe into his groin.

79. Escape From One-Arm Strangle Hold From the Rear

When your opponent attacks as shown in figure 70 ①, reach up with your left hand and grasp his clothing at his right elbow. Pull down on his elbow and, at the same time, tuck your chin into its crook so he cannot choke you. Grasp your opponent's right shoulder with your right hand (fig. 70 ②). Push backward with your buttocks against his mid-section, retaining your hold on his upper arm and shoulder with both hands. Bend from the waist swiftly and throw your opponent over your head and to the ground (fig. 70 ③).

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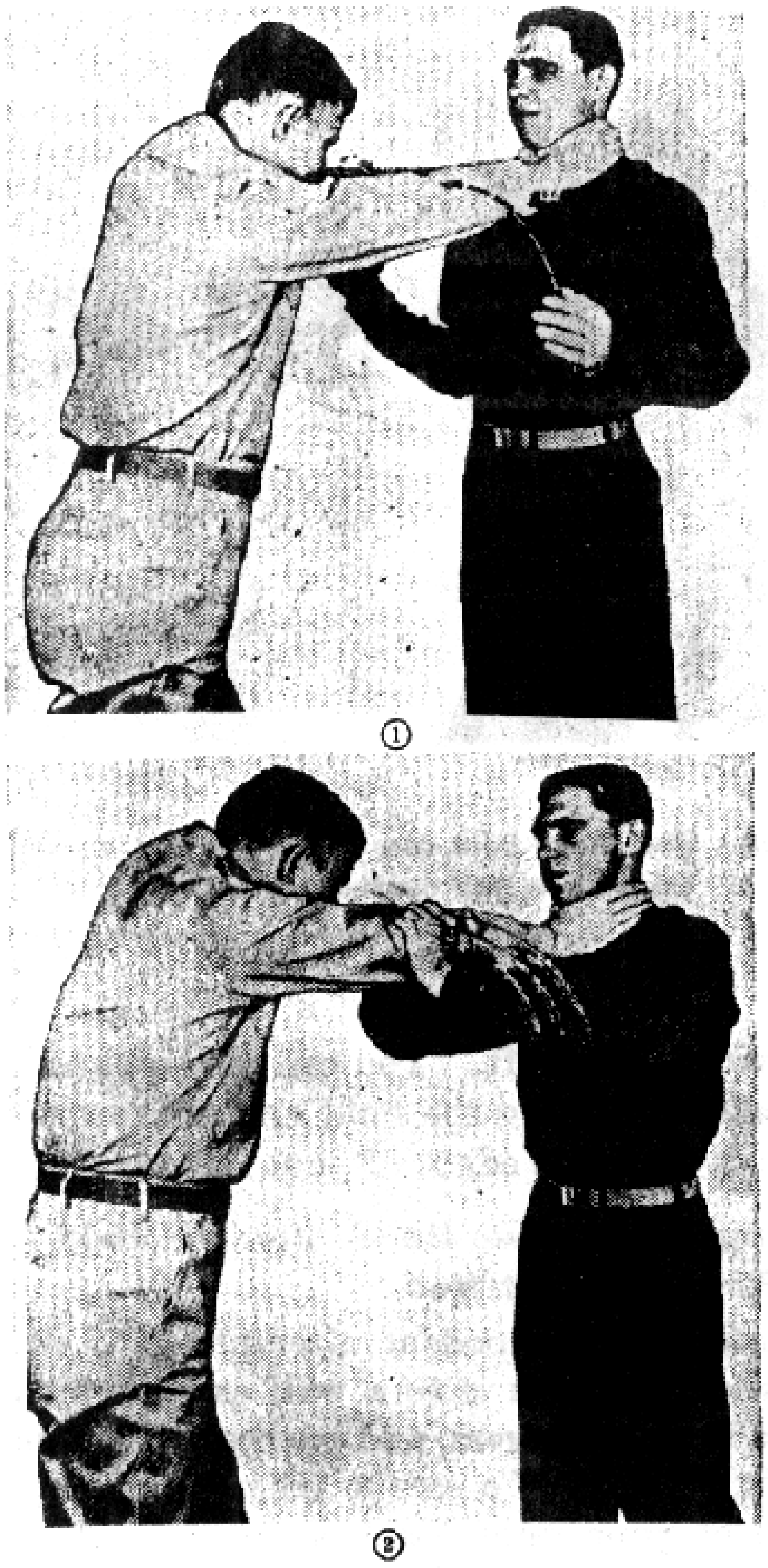

Figure 69. Escape from two-hand front strangle hold when pinned against wall.

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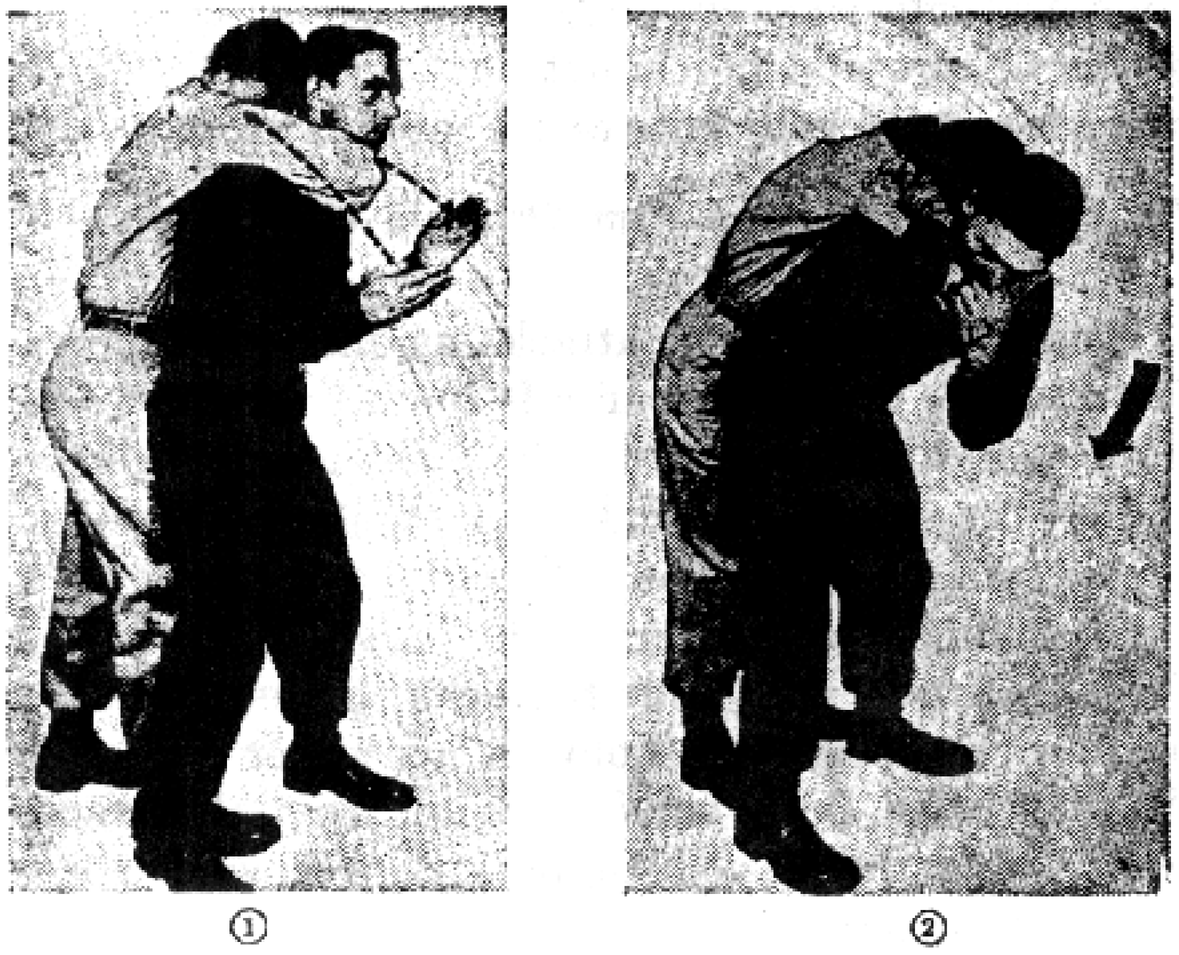

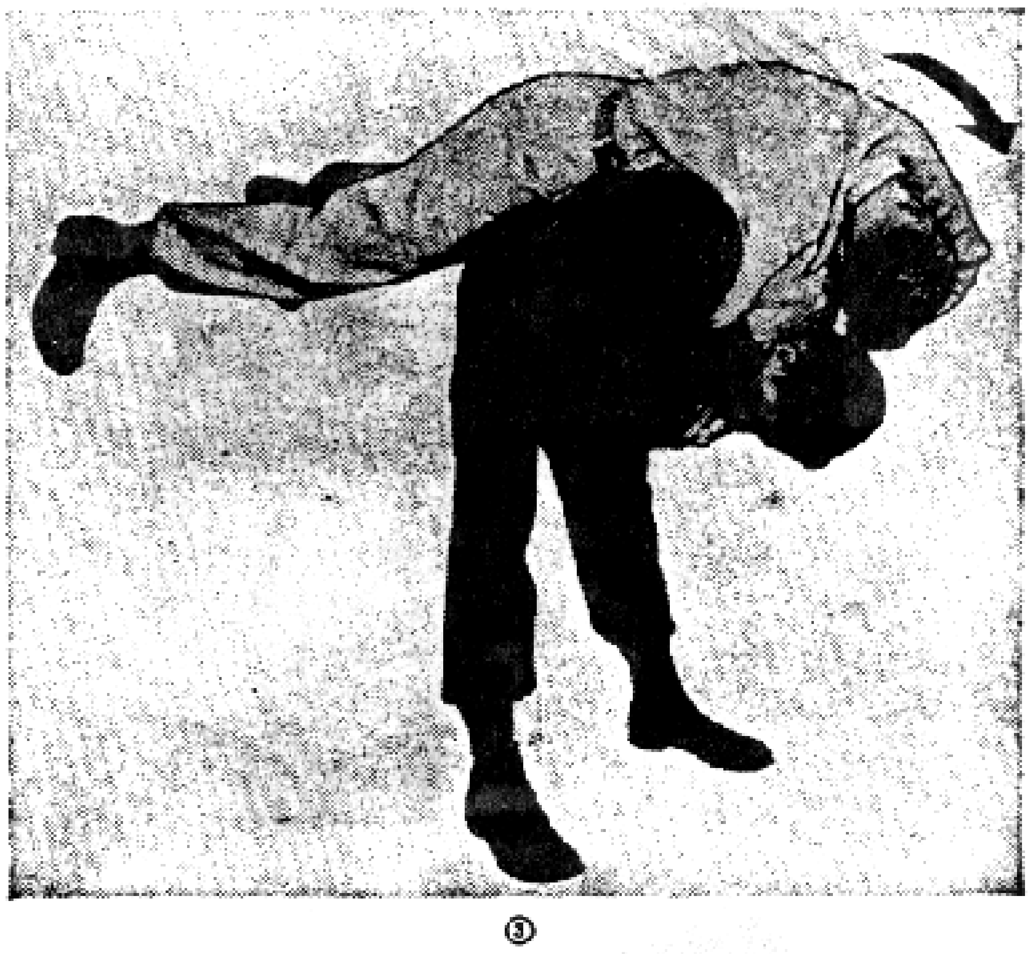

Figure 70. Escape from one-arm strangle hold from the rear.

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80. Escape From Front Overarm Bear Hug

When your opponent has grasped you around the body and pinned both your arms as shown in figure 71 ①, bring your thumbs into his groin, forcing his hips backward and leaving a space between your hips and his (fig. 71 ②). Pivot on your left foot and place your right foot outside of your opponent's right foot. Slip your right arm under his left armpit and grasp him across the back. Your left hand grasps his right upper arm, pulling it forcefully. Force your buttocks into his midsection and, at the same time, twist to your left. Lift with your right arm and pull with your left hand, throwing your opponent over your hip and to the ground (fig. 71 ③).

81. Escape From Overarm Rear Body Hold

When your opponent attacks as shown in figure 72 ①, loosen his grip by stepping on his instep or kicking his shins. Raise your elbows shoulder high and, at the same time, lower your body quickly by bending your knees (fig. 72 ②). Then drive your elbow into his midsection (fig. 72 ③). Continue the movement by reaching up with your right hand and grasping his right upper arm just above his elbow. With your left hand, grip his right wrist and throw him over your head (fig. 72 ④ and ⑤. He will hit the ground on his back presenting a good target to attack.

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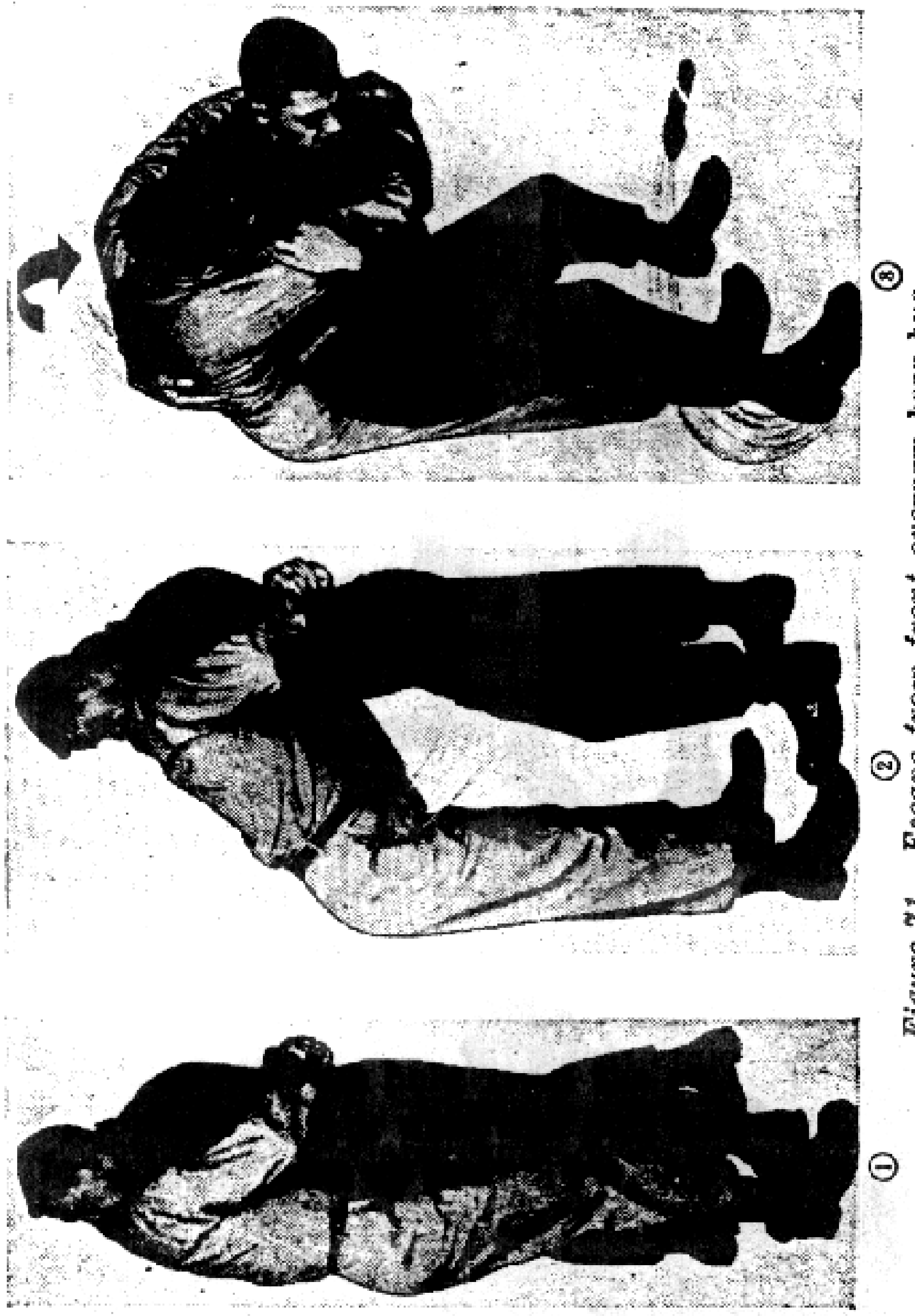

Figure 71. Escape from front overarm bear hug.

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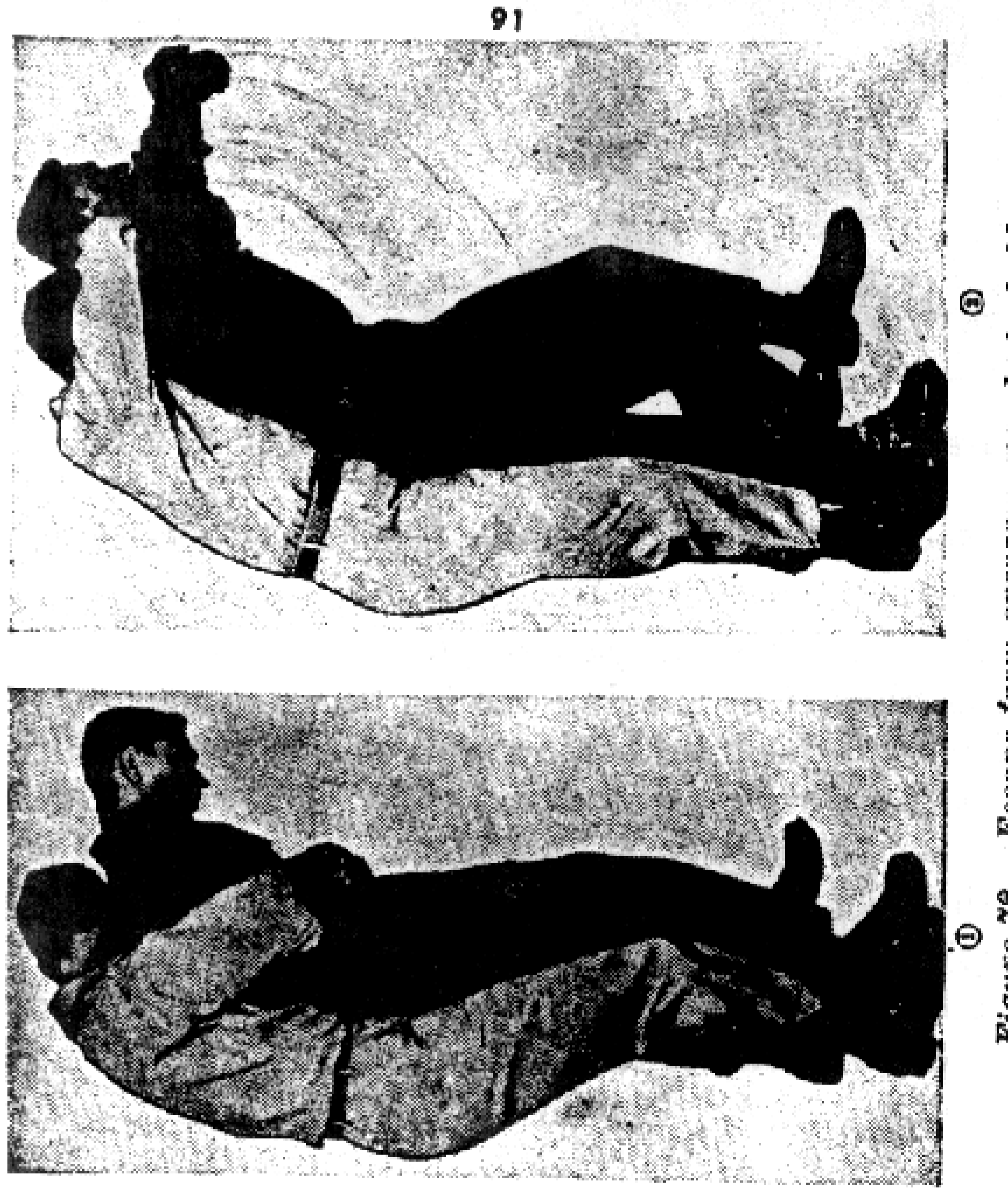

Figure 72. Escape from overarm rear body hold.

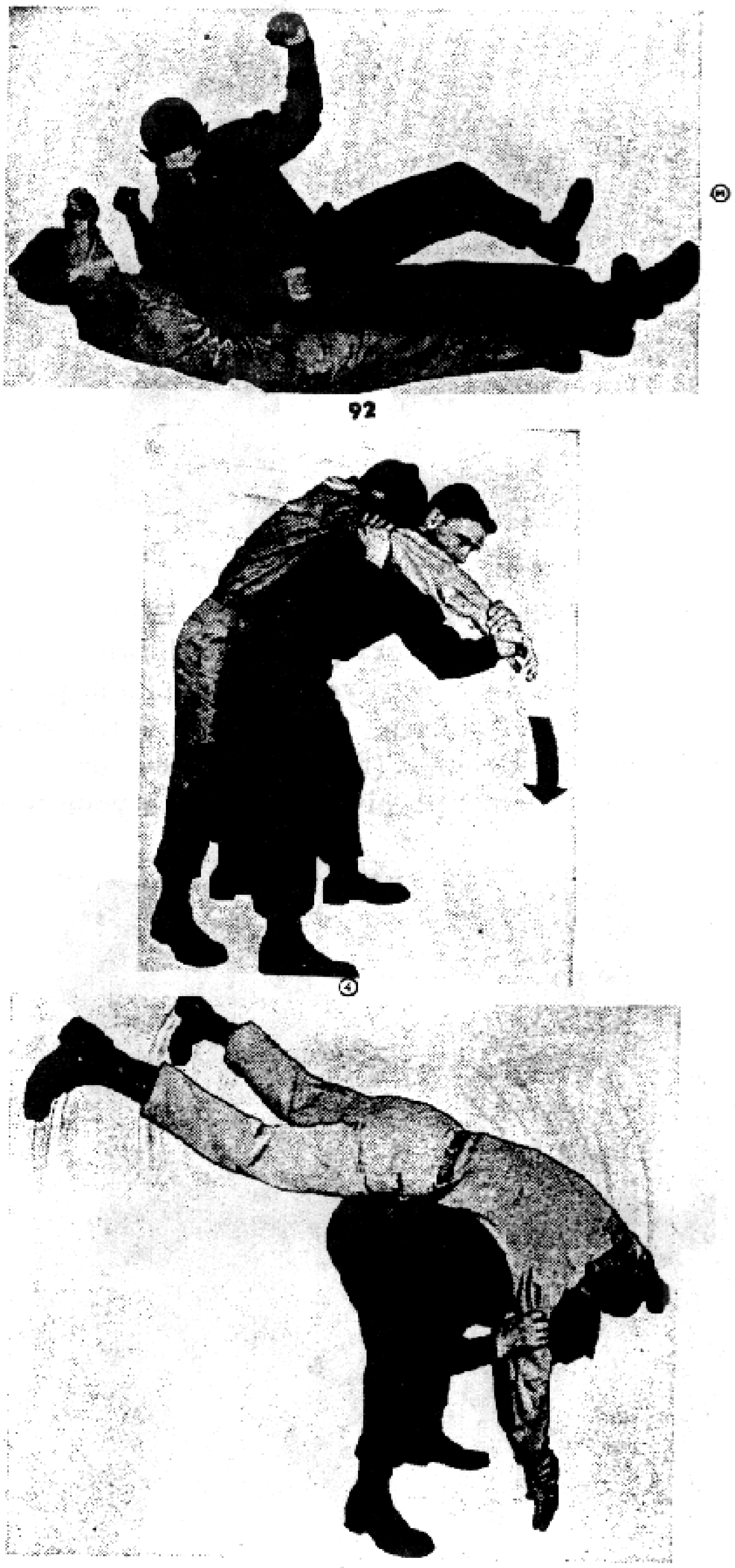

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Figure 72. Escape from overarm rear body hold—

93

82. Escape From Front Underarm Bear Hug

Figure 73 ① shows that your opponent has locked his arms around your waist and is attempting to bend you over backward. Close the fingers of your left hand and place the thumb underneath the base of his nose. Put your right arm around his waist. By pressing with your left thumb and pulling his waist toward you, he either loosens his grip or is forced backward (fig. 73 ②).

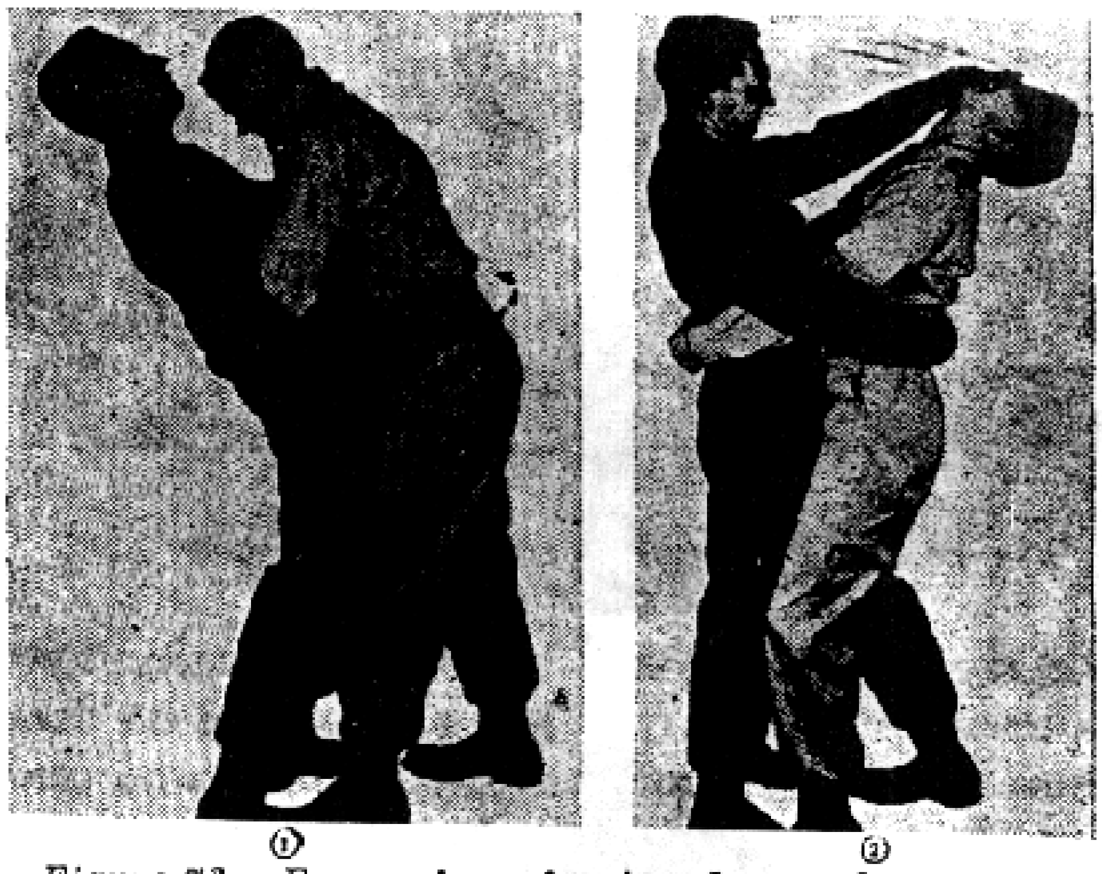

Figure 73. Escape from front underarm bear hug.

83. Escape From Rear Underarm Body Hold

When your opponent grasps you as shown in figure 74 ①, reach down with your left hand and place it just above his left knee. Press down on this spot with most of your weight (fig. 74 ②). You now have a firm base on which to pivot. Lift both your feet from the ground and switch your left leg behind your opponent's right leg. As soon as your feet are firmly planted on the ground, bring your left hand under your opponent's left knee and your right hand under his right knee (fig. 74 ③). Lift up and raise him off the ground (fig. 74 ④). If your opponent releases his hold, you can drive his head into the ground. If he keeps his hold, fall on him and force his head into the ground.

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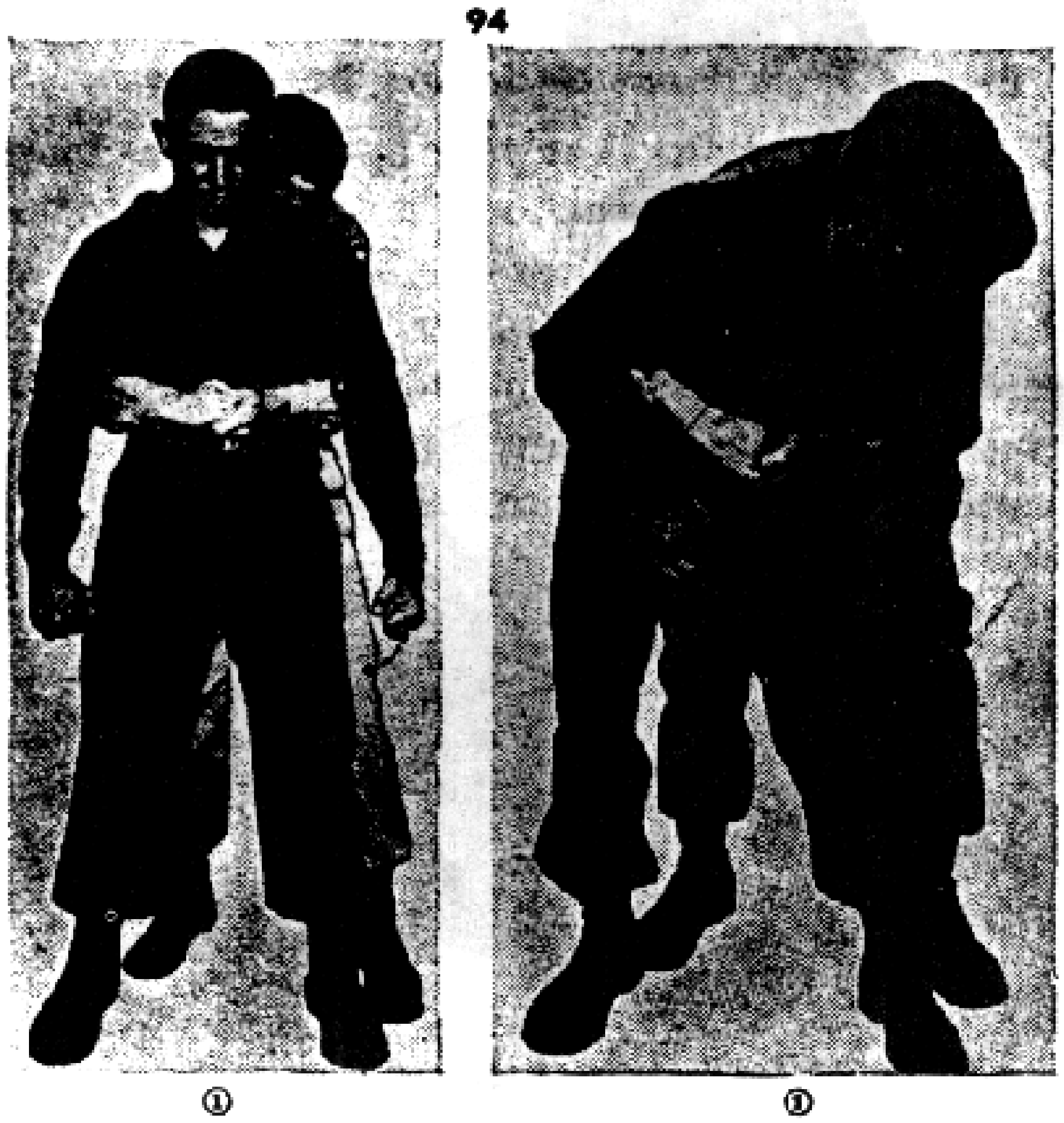

Figure 74. Escape from rear underarm body hold.

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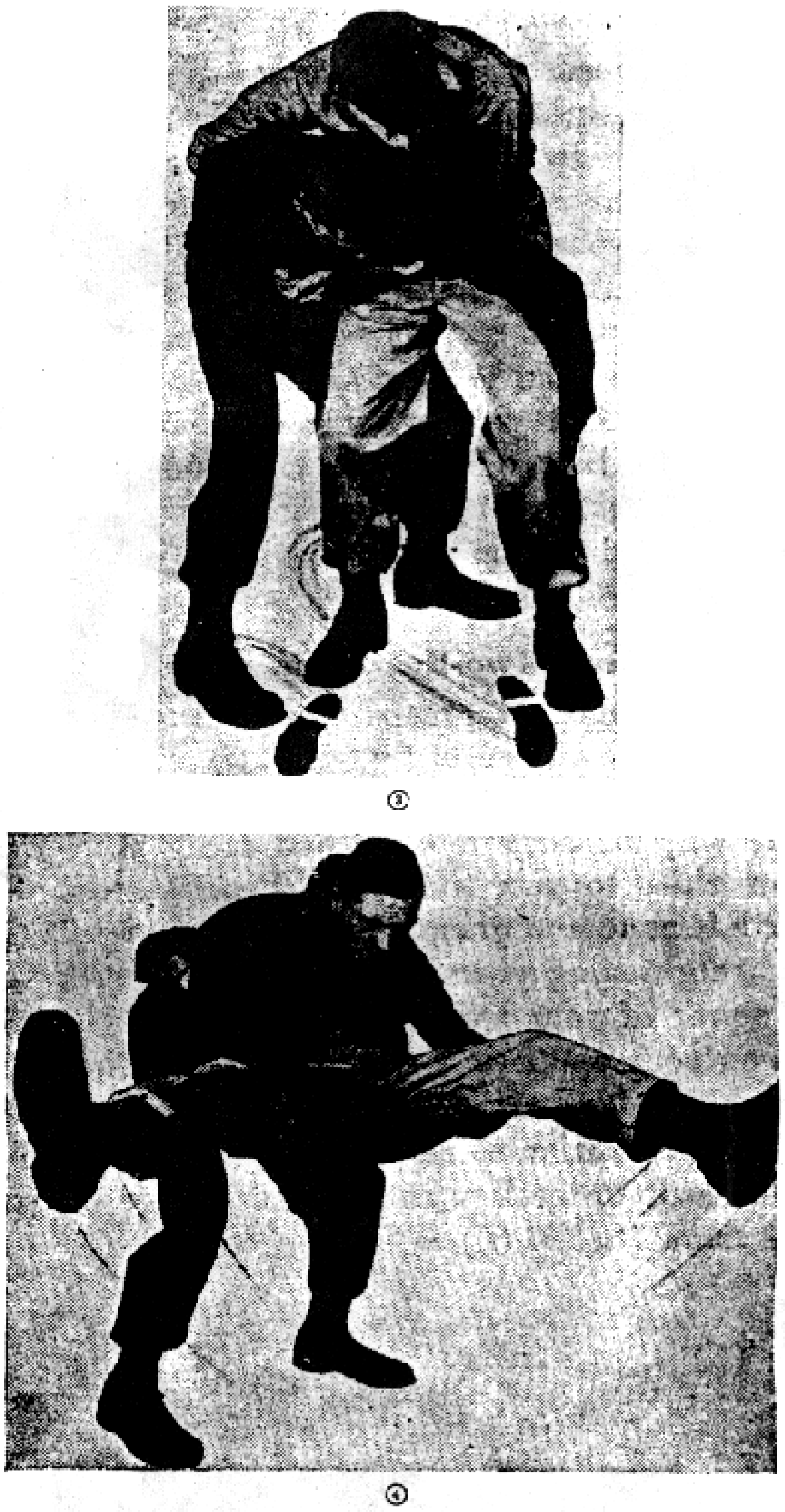

Figure 74. Escape from rear underarm body hold—Con.

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84. Second Escape From Rear Underarm Body Hold

Your opponent uses the same grasp around your waist as explained in paragraph 83, but this time he braces himself by placing one leg between your legs and putting his head behind your shoulder blade out of reach of your arms (fig. 75 ①). To break this hold, bend swiftly from the waist and grasp the ankle of the foot which he has between your legs (fig. 75 ②). Keep your hold on his ankle and straighten your body. This puts pressure on your opponent's knee, causing him to release his hold and drop on his back (fig. 75 ③). If your opponent keeps his hold, fall backward on top of him, driving your weight into his midsection.

85. Escape From Two-Hand Grip on One Wrist

If your opponent grasps your right wrist with both hands as shown in figure 76 ①, step forward with your right foot and bend both knees. Keep the trunk of your body upright and bring your right elbow close to your stomach. Reach across with your left hand and grasp your right fist (fig. 76 ②). By straightening your legs and pulling back with the power of your body and arms, you bring pressure on your opponent's thumbs, forcing him to release his hold. At the completion of the escape, you are in position to deliver a blow to your opponent's head or neck with the knife edge of your right hand (fig. 76 ③).

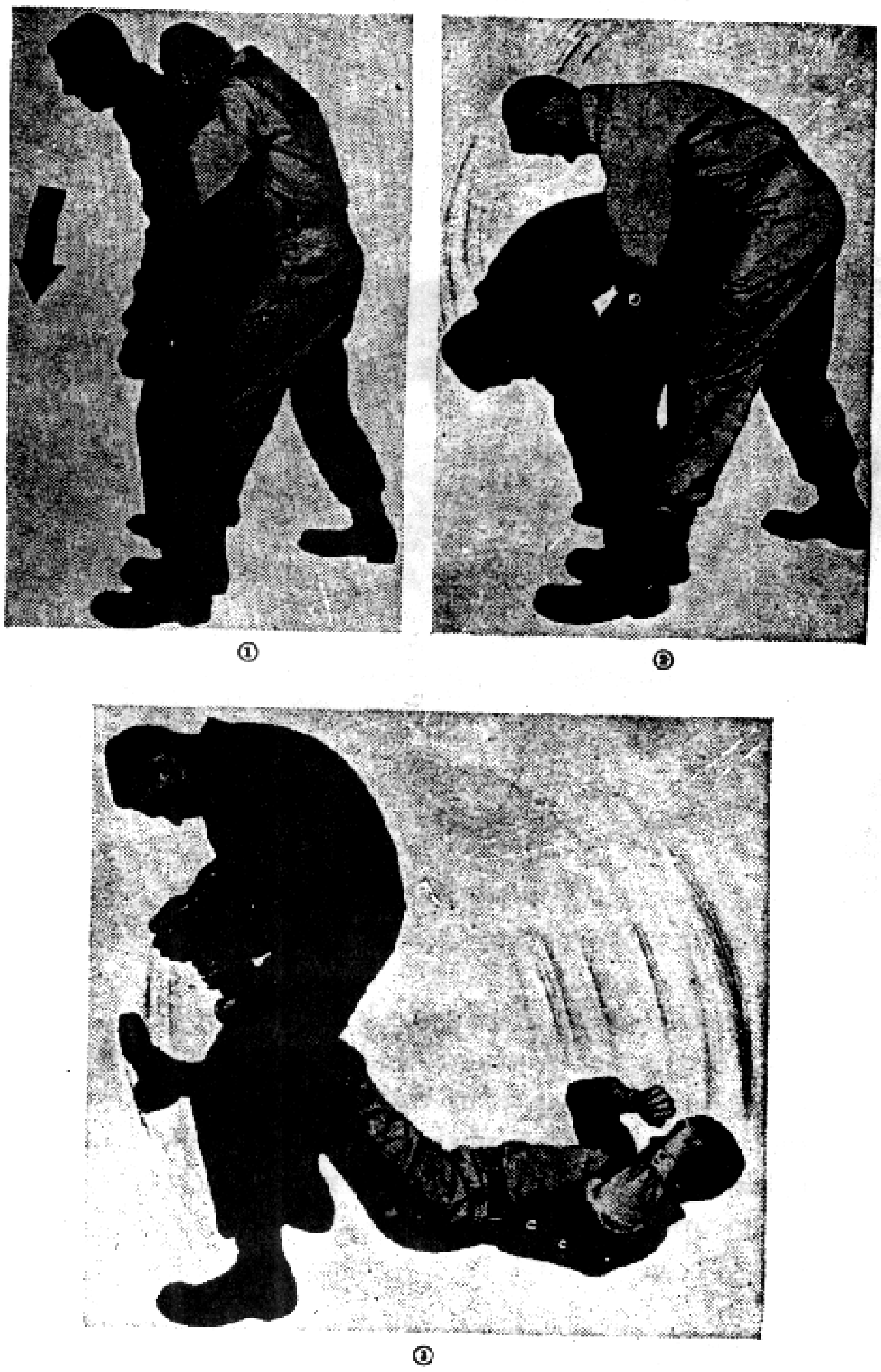

Figure 75. Second escape from rear underarm body hold.

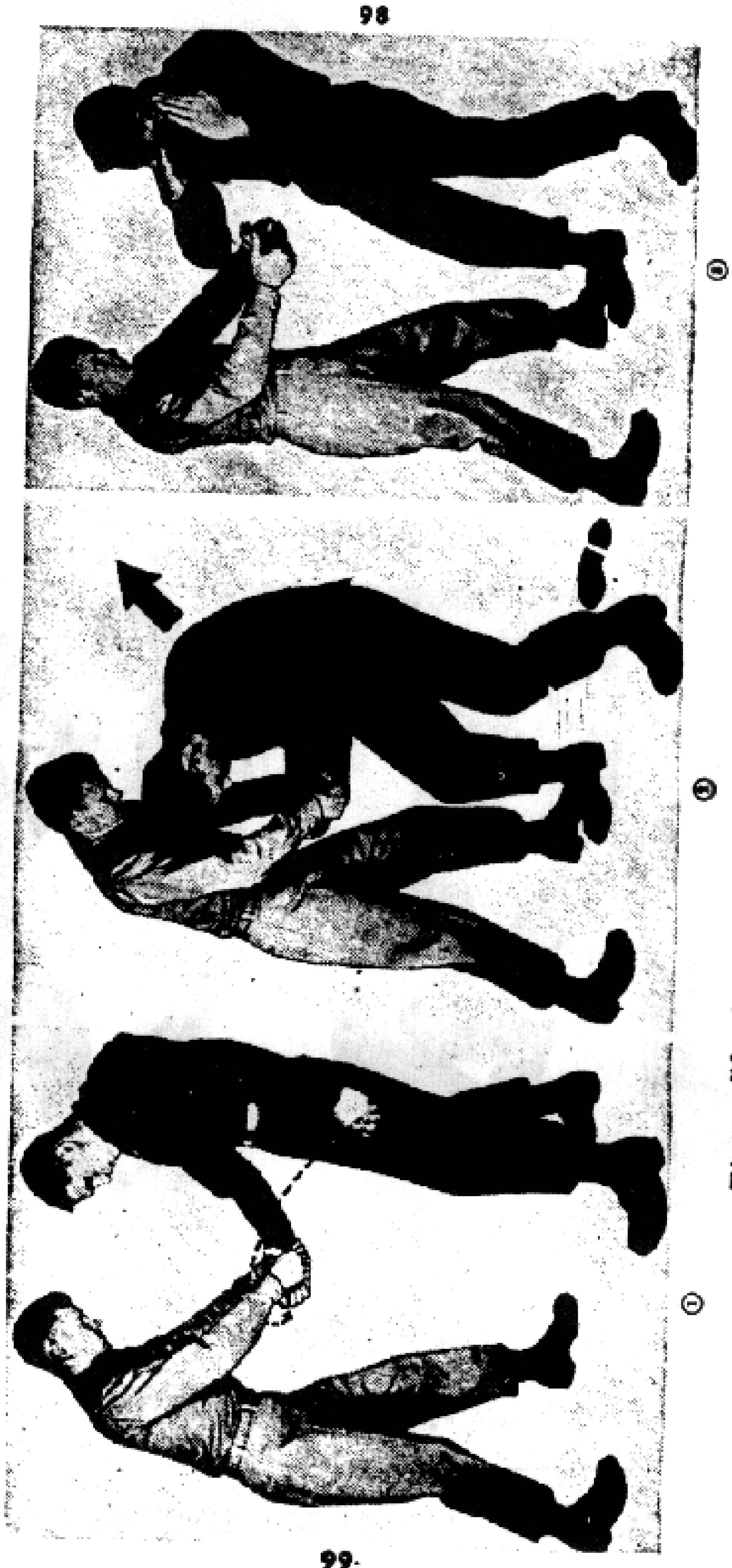

Figure 76. Escape from two-hand grip on one wrist.

86. Escape From Two-Hand Overhand Grip on Both Wrists

If your opponent grasps your wrists as shown in figure 77 ①, step forward with either foot and bend both knees. At the same time, bend your arms so the elbows are close to the lower abdomen (fig. 77 ②). Execute the escape by straightening your legs, pulling back with your body, and pushing your arms upward in one motion (fig. 77 ③). The faster you work this escape, the more effective it is.

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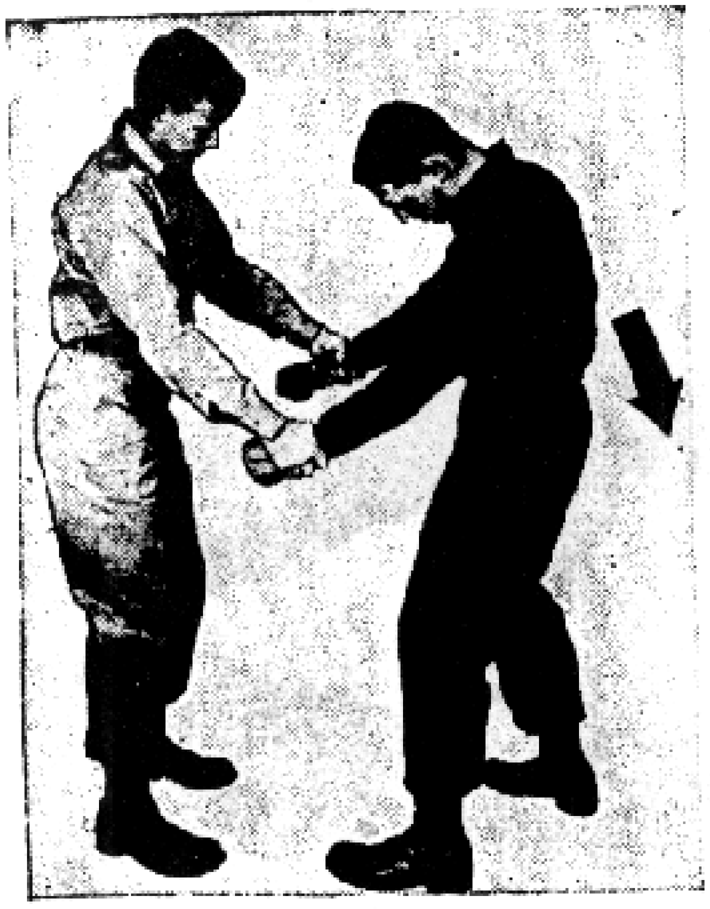

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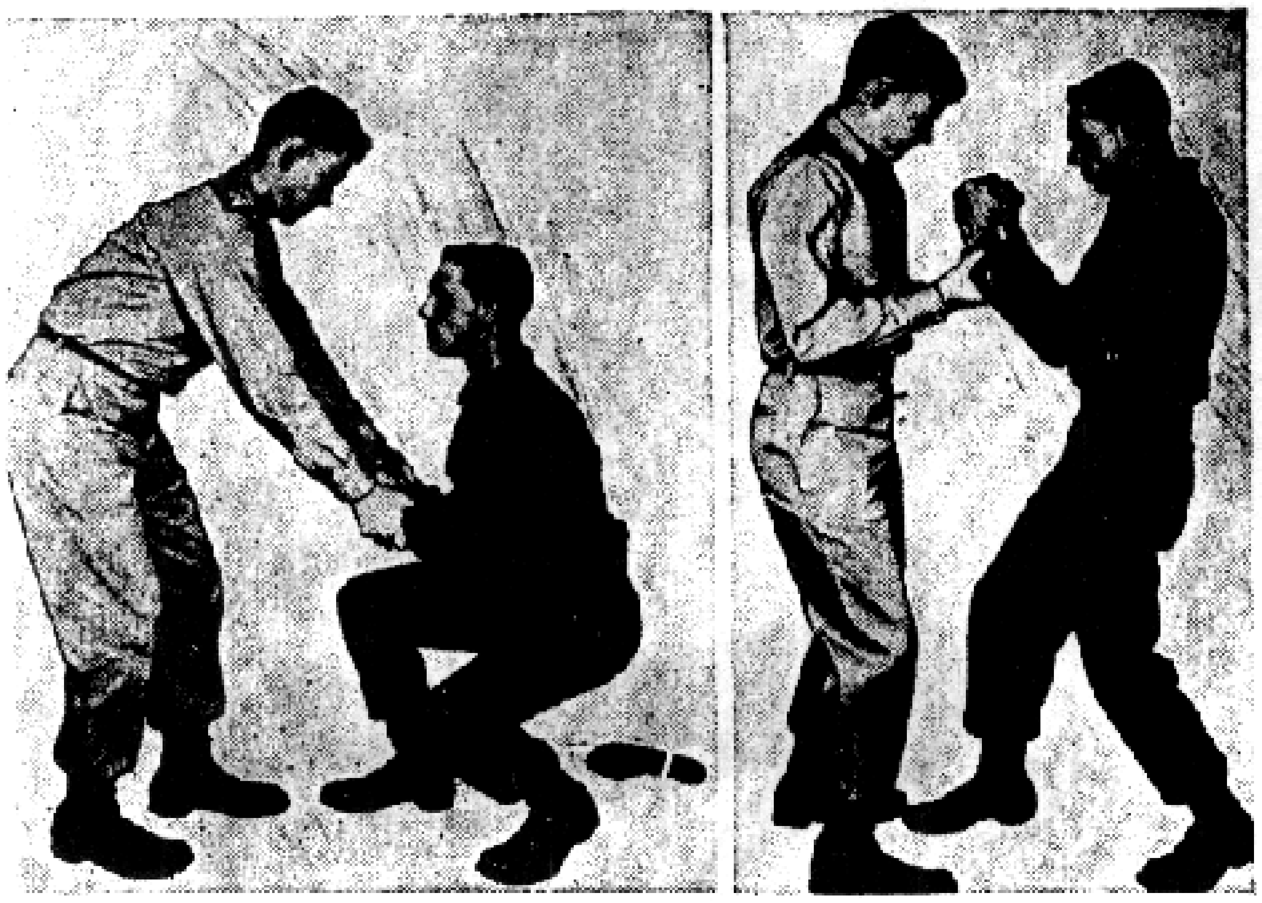
Figure 77. Escape from two-hand overhand grip on both wrists.



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CHAPTER 8

DISARMING METHODS

Section I. BAYONET DISARMING

87. General

In training, you are taught bayonet disarming methods for both long thrust and short thrust attacks. In combat, however, any of the methods described in this section can be used to disarm an opponent whether he uses a long thrust or a short thrust. The reason the text differentiates between a short thrust and a long thrust is to enable you to gage the distance between the point of the bayonet and your body when practicing these techniques. When practicing the short thrust, you should be approximately arm's distance from the point of the bayonet. When practicing the long thrust, the distance is increased one foot. The unarmed man in training should wait until the armed man has committed himself before going into his disarming maneuver.

88. Counter Against Short Thrust

a. If your opponent attacks you with a short thrust, twist your body to the left but keep your feet in place. At the same time, slap your right forearm or wrist against the barrel of his rifle, deflecting the bayonet from your body (fig. 78 ①).

b. As soon as the bayonet has passed your body, grasp your opponent's left hand with your right hand. At the same time, take a long step with your left foot toward your opponent's right, reach under the rifle with your left hand, and press your left shoulder against the upper handguard. With your left hand, grasp his right hand where it holds the top of the small of the stock (fig. 78 ②).

c. Pull with your left hand and push with your right hand. Keep your weight on your left foot and kick your attacker with the calf of your right leg behind the knee joint of his right leg (fig. 78 ③). Your opponent will fall to the ground and loosen his grip on the rifle.

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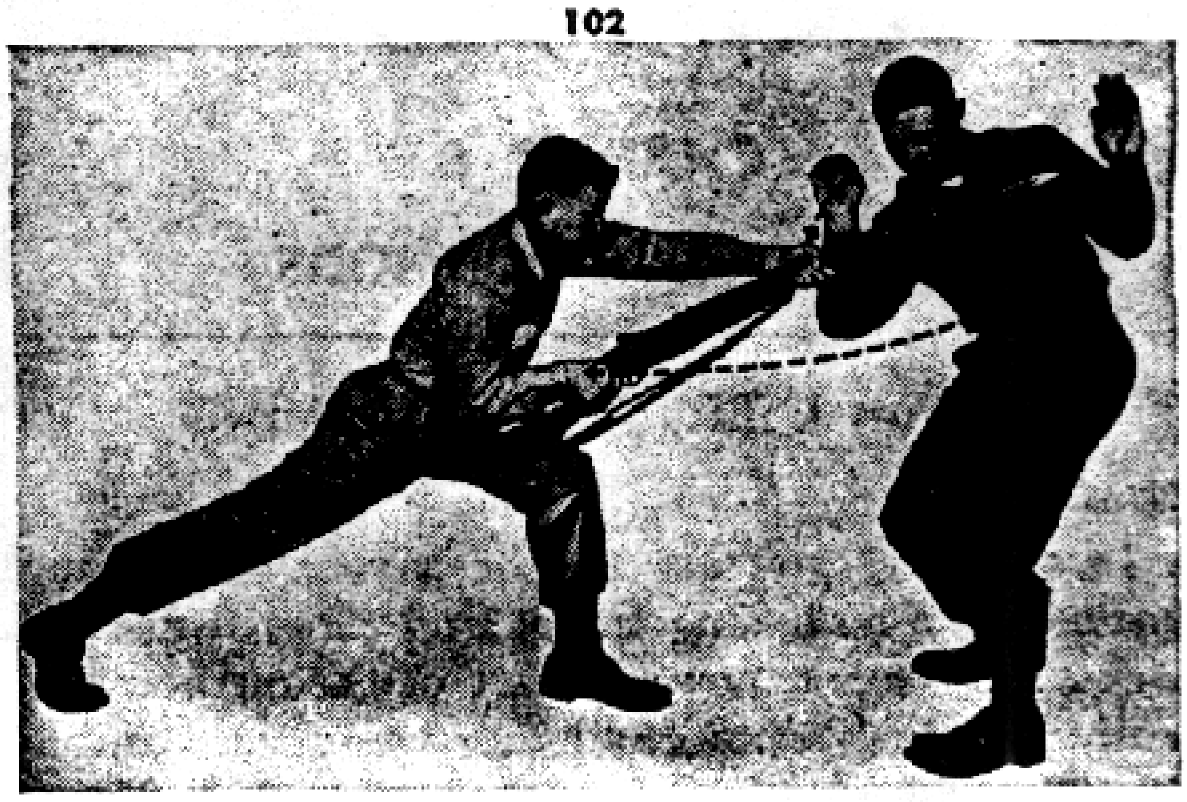

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Figure 78. Counter against short thrust.

89. Second Counter Against Short Thrust

a. As your opponent makes his thrust, use the heel of your right hand to parry his bayonet to your left and, at the same time, side-step to your right oblique. You are now in a position facing the rifle from the side with your groin area protected by your right leg (fig. 79 ①).

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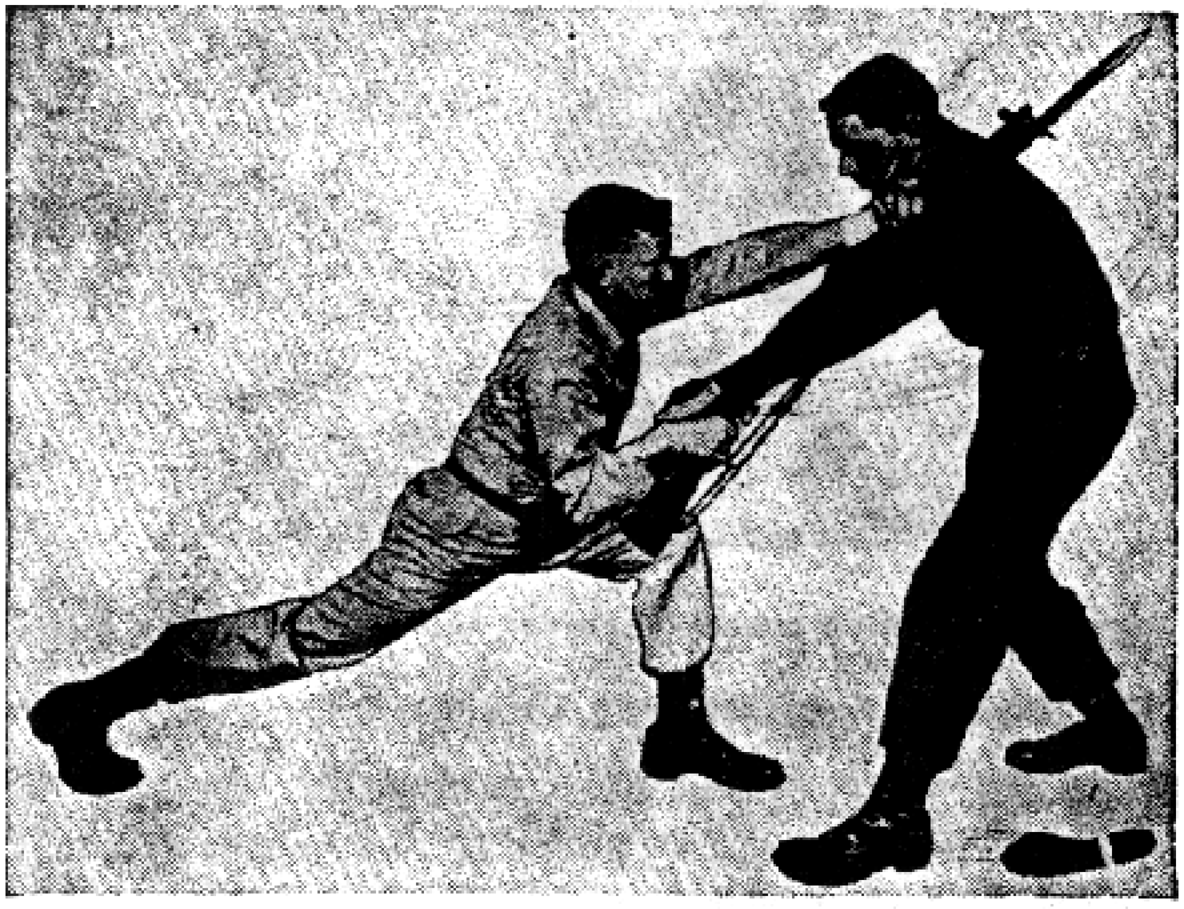

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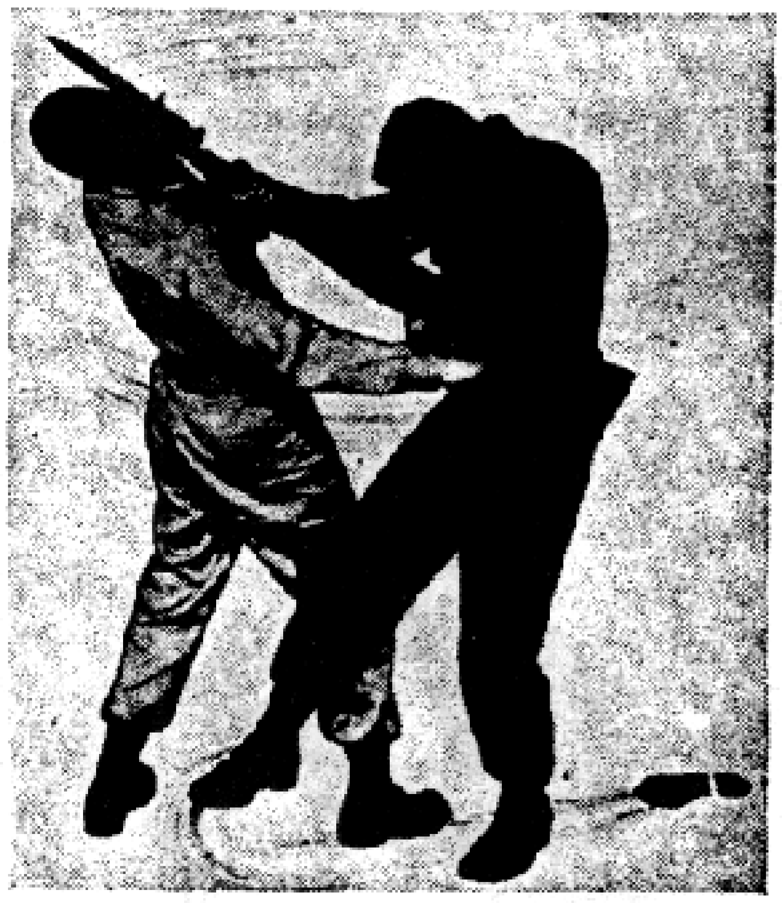

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Figure 78. Counter against short thrust—Continued.

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b. With your left hand, palm up, grasp the rifle on the upper handguard. At the same time, strike the inside of your opponent's left elbow sharply with the knife edge of your right hand (fig. 79 ②).

c. Keep a firm hold on the rifle. Step through with your left foot, moving quickly past your attacker on his left, and jerk the rifle up and backward in an arc over his shoulder (fig. 79 ③). If he keeps his hold on the rifle, kick him and yank the rifle loose. Whirl and attack him with the bayonet.

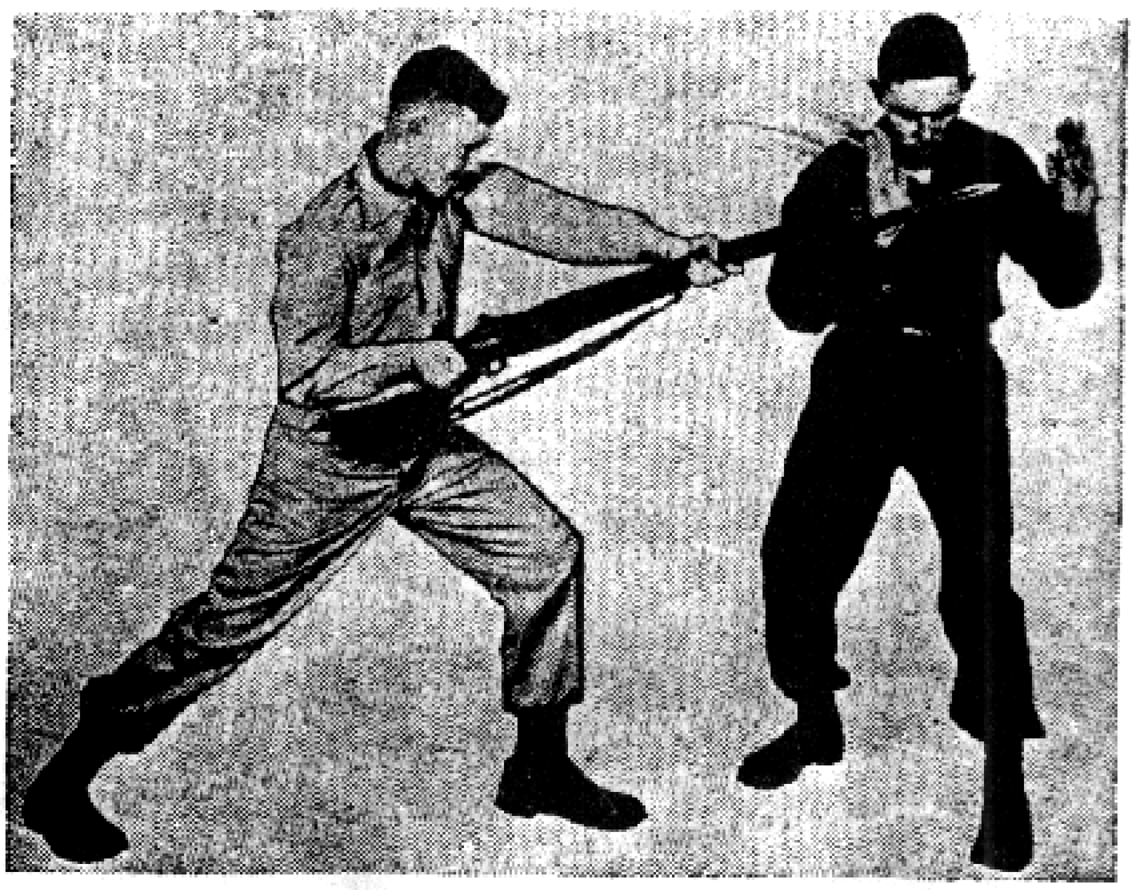

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Figure 79. Second counter against short thrust.

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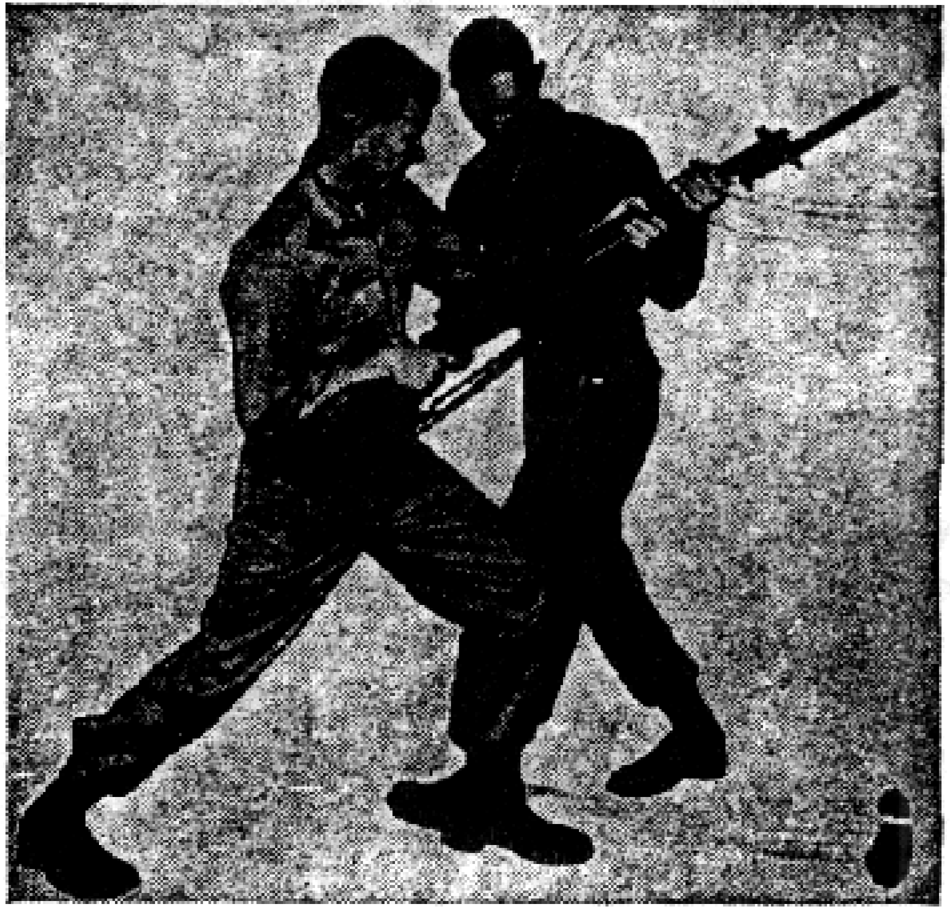

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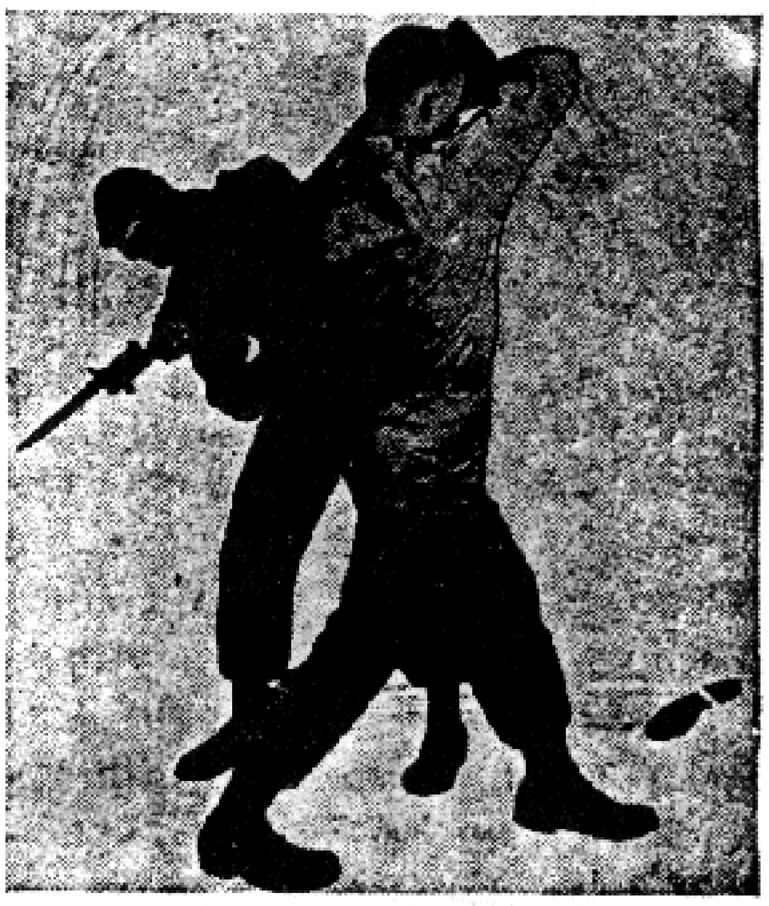

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Figure 79. Second counter against short thrust—Continued.

106

90. Third Counter Against Short Thrust

a. As your opponent makes his thrust, use the heel of your left hand to parry the bayonet to your right and side-step to your left oblique. You are now in position facing the side of the rifle with your groin area protected by your left leg (fig. 80 ①).

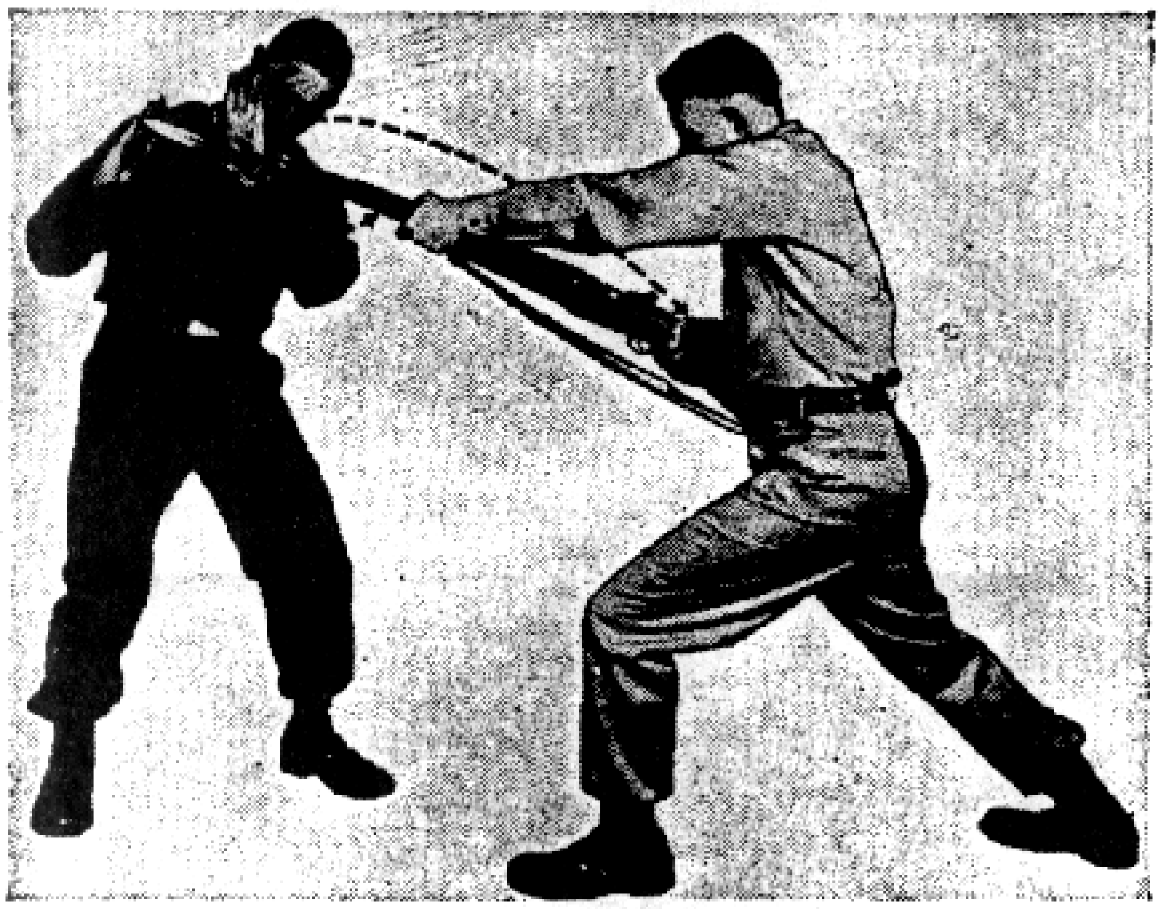

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Figure 80. Third counter against short thrust.

b. With your right hand, palm up, grasp the rifle anywhere on the upper handguard and with the left hand, palm down, grasp the receiver (fig. 80 ②).

c. Keep a firm hold on the rifle with both hands and step through with your right foot, moving quickly past your opponent. Jerk the rifle sharply up and backward in an arc over the attacker's shoulder and twist it out of his hands (fig. 80 ③). Whirl and smash him with the butt or attack him with the bayonet.

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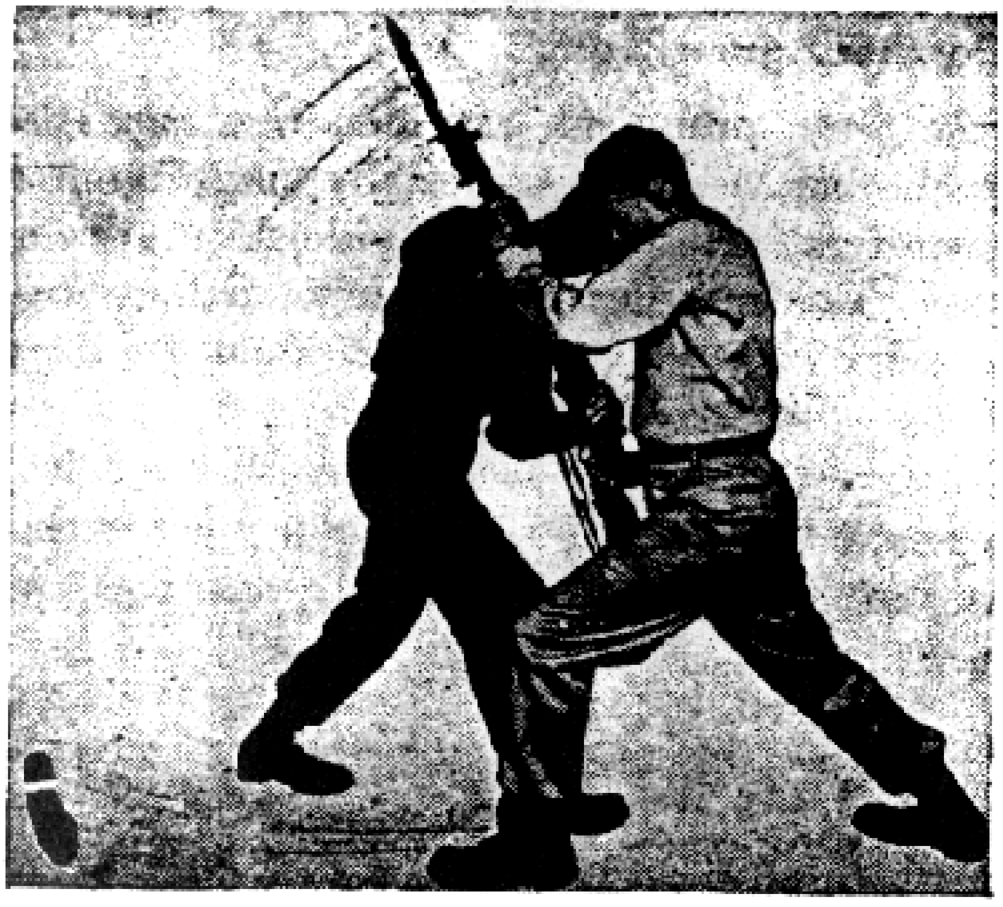

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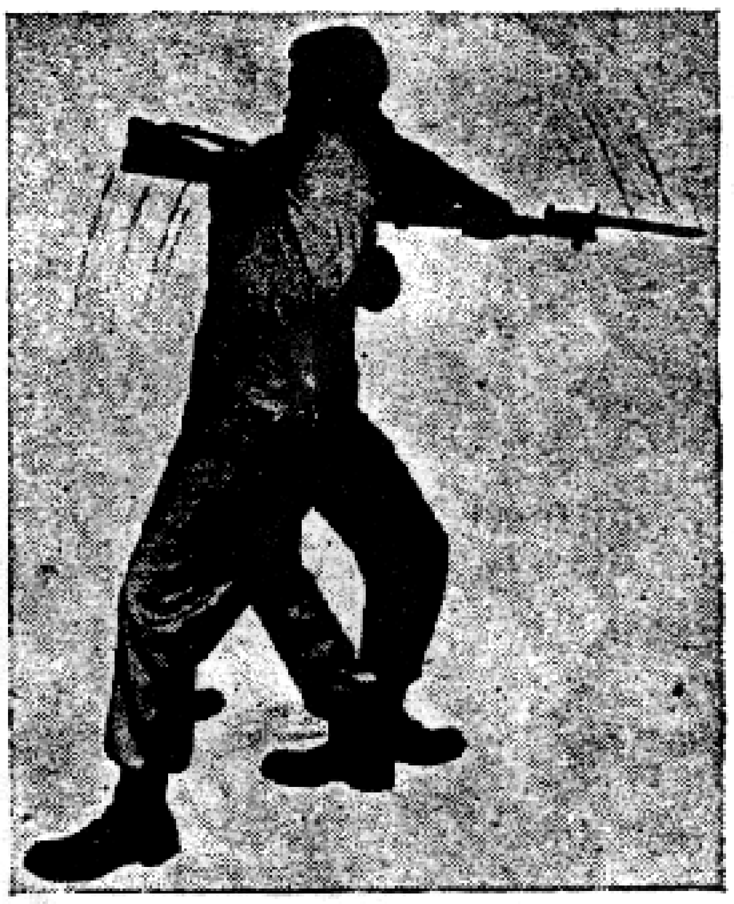

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Figure 80. Third counter against short thrust—Continued.

108

91. Counter Against Long Thrust

a. As your opponent executes the long thrust, parry the bayonet to your left by slapping it with the heel of your right hand and side-step to the right oblique. You are now in a position facing the side of the rifle with your groin area protected by your right leg (fig. 81 ①). With your left hand, palm up, grasp your opponent's left hand and the rifle from underneath (fig. 81 ②). Twist your body to the left in front of your opponent and place your right leg in front of his body (fig. 81 ③).

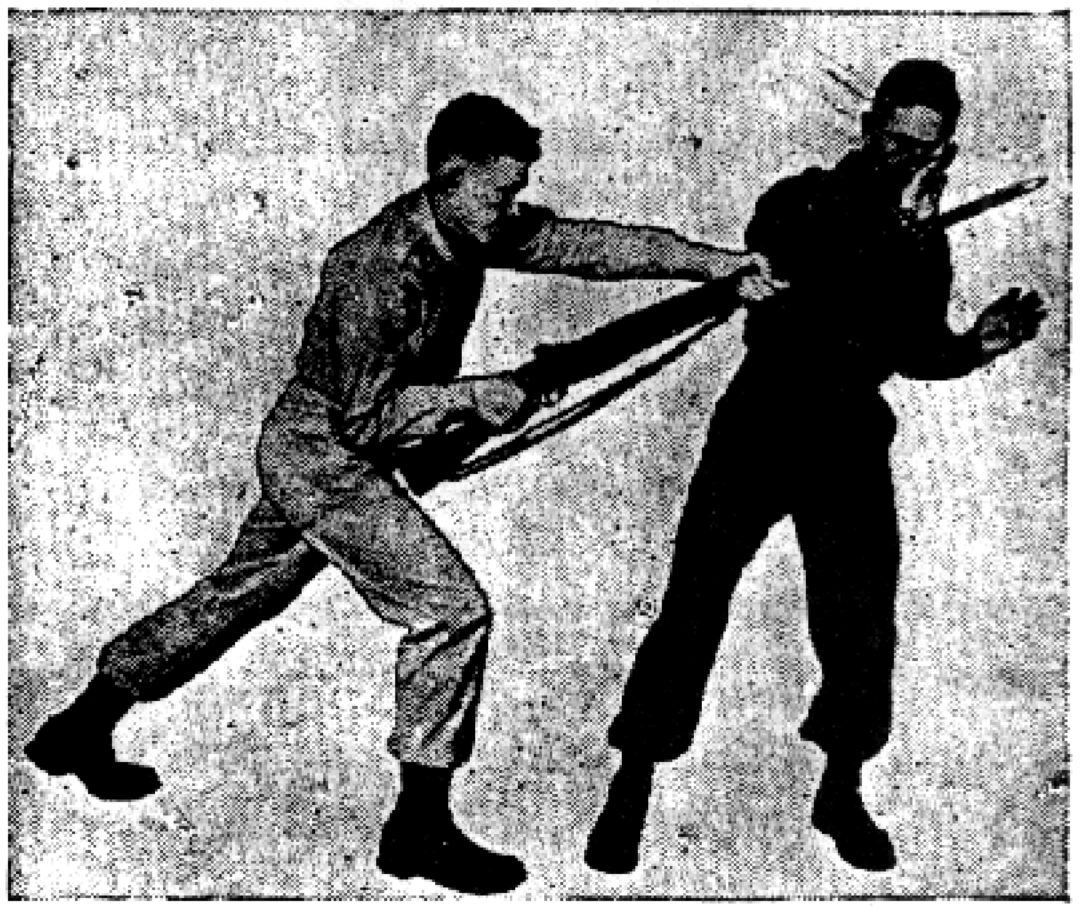

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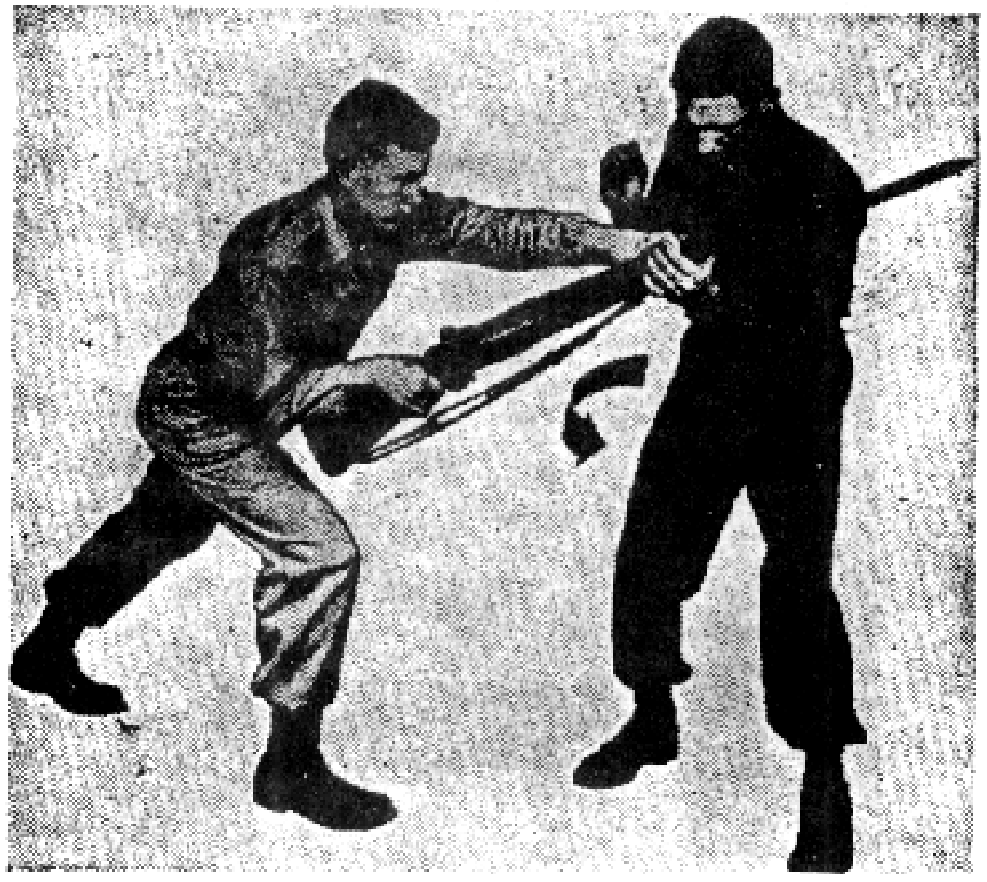
Figure 81. Counter against long thrust.

b. With the right hand, palm down, grasp your opponent's left hand and rifle from above. Twist the rifle and pull your opponent across your right leg. At the same time, exert pressure with the right



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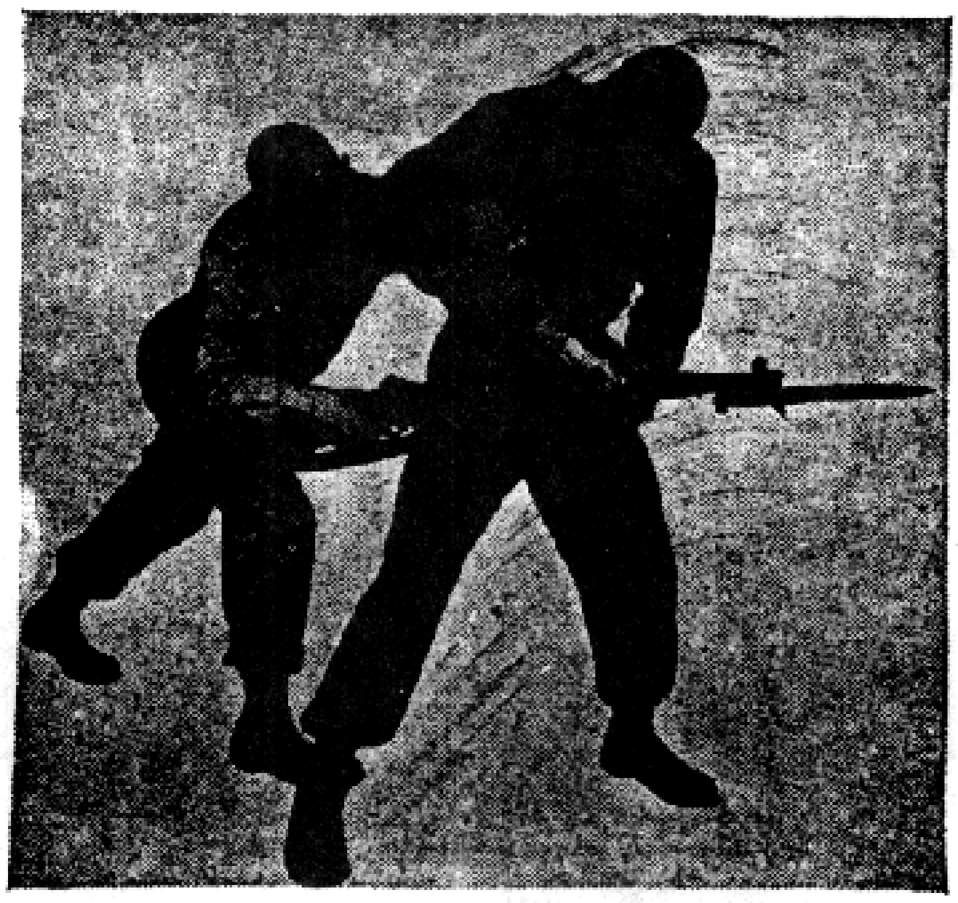

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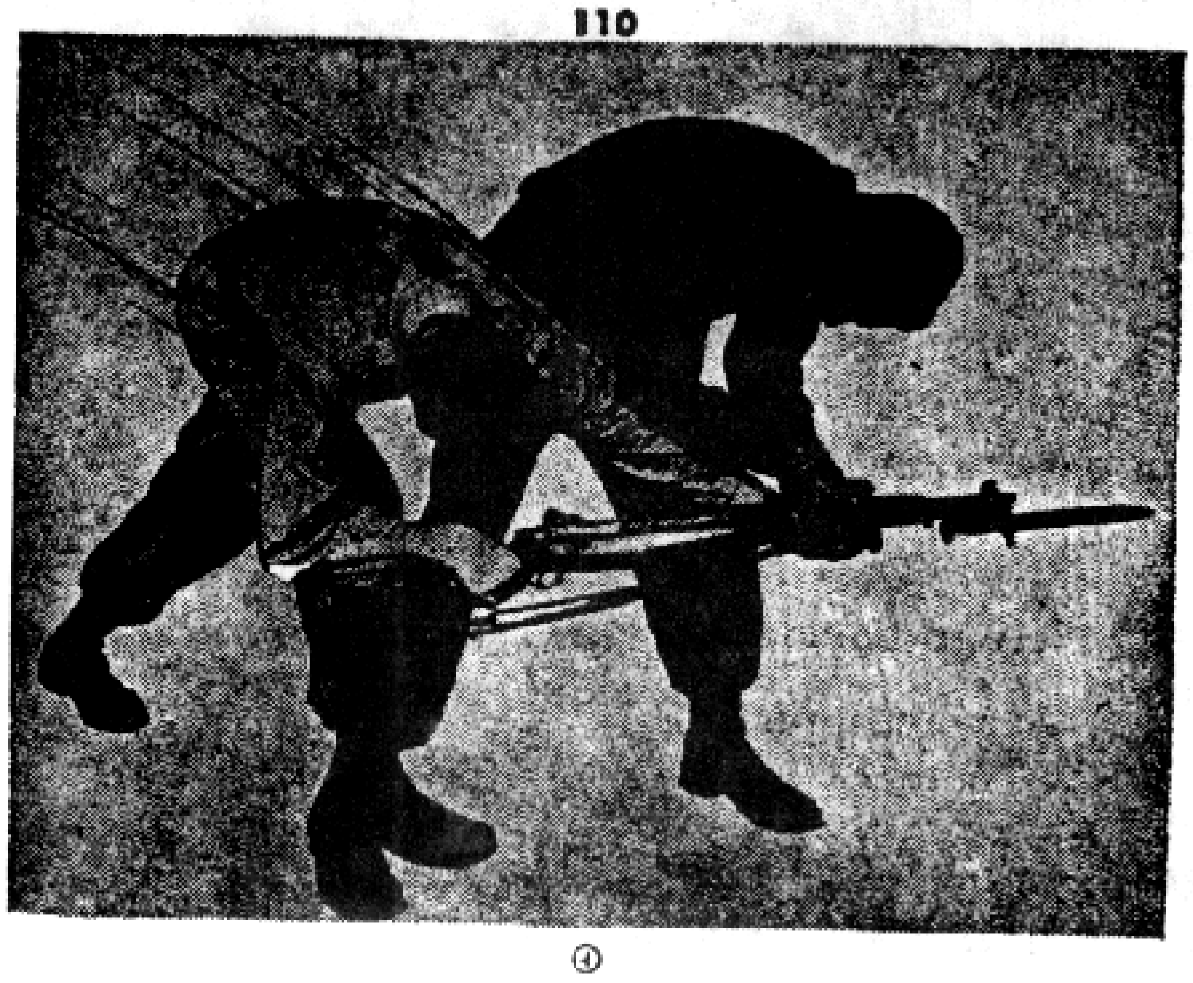
Figure 81. Counter against long thrust—Continued.



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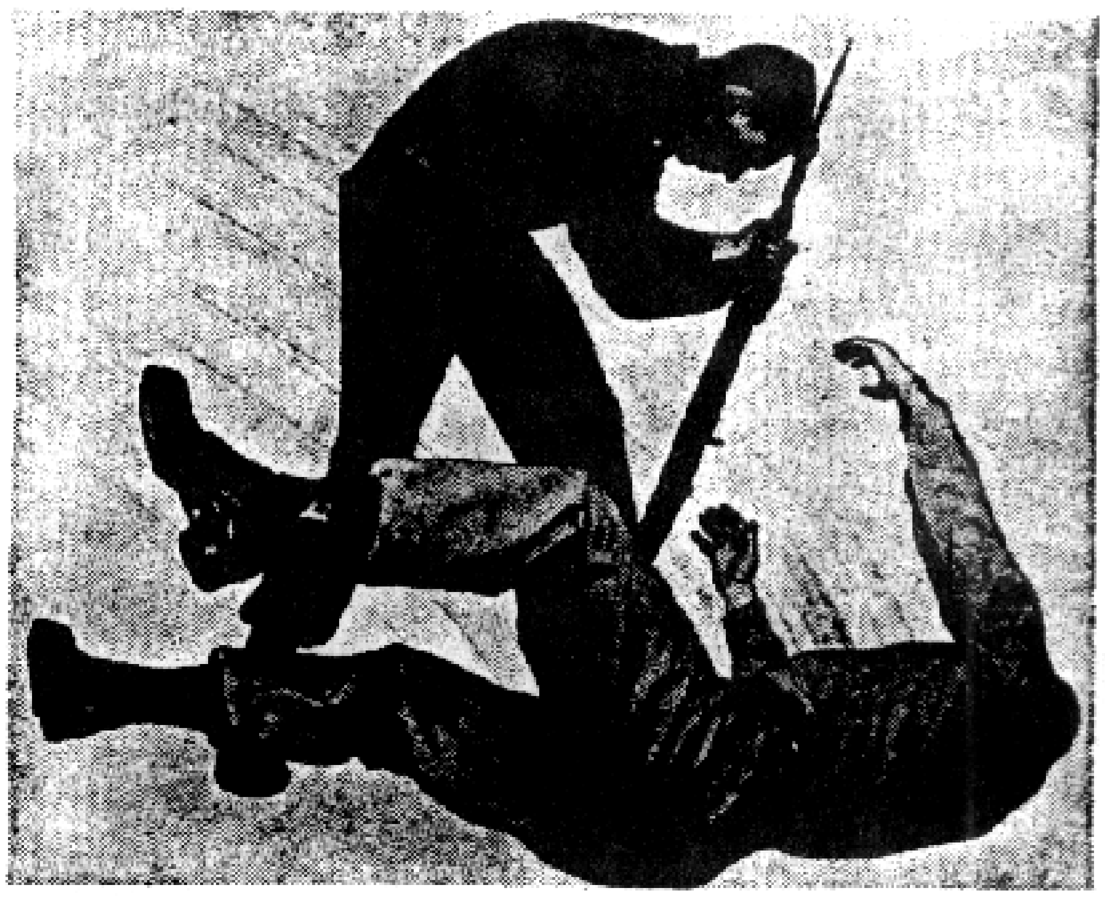


⑤

Figure 81. Counter against long thrust—Continued.

elbow against the outside of his left arm and elbow (fig. 81 ④). Sufficient pressure downward with your elbow, while twisting and pulling up on the rifle, can break your opponent's elbow.

c. Continue the twisting motion, pulling your opponent completely across your leg and throwing him to the ground (fig. 81 ⑤). Regrasp the rifle and follow through with an attack.

92. Second Counter Against Long Thrust

a. As your opponent executes the long thrust, parry his bayonet to your right with a sharp slapping movement with the heel of your left hand. As you parry with your left hand, move your body to the left oblique, stepping off to your left front with your left foot. You are now in position facing the rifle from the side with your groin area protected by your left leg (fig. 82 ①).

b. Strike the open palms of both hands down on the rifle near the muzzle, driving the point of the bayonet into the ground (fig. 82 ②). Do not follow the rifle all the way to the ground, but allow your opponent's momentum to imbed the bayonet into the ground.

c. Grasp the butt of the rifle with your left hand and with the right hand grasp your opponent anywhere on his back or head (fig. 82 ③). To completely disarm him, drive the stock of the rifle into your opponent's body and, at the same time, pull him with your right hand, spinning him to the ground (fig. 82 ④). You are now in position to recover the rifle and attack him.

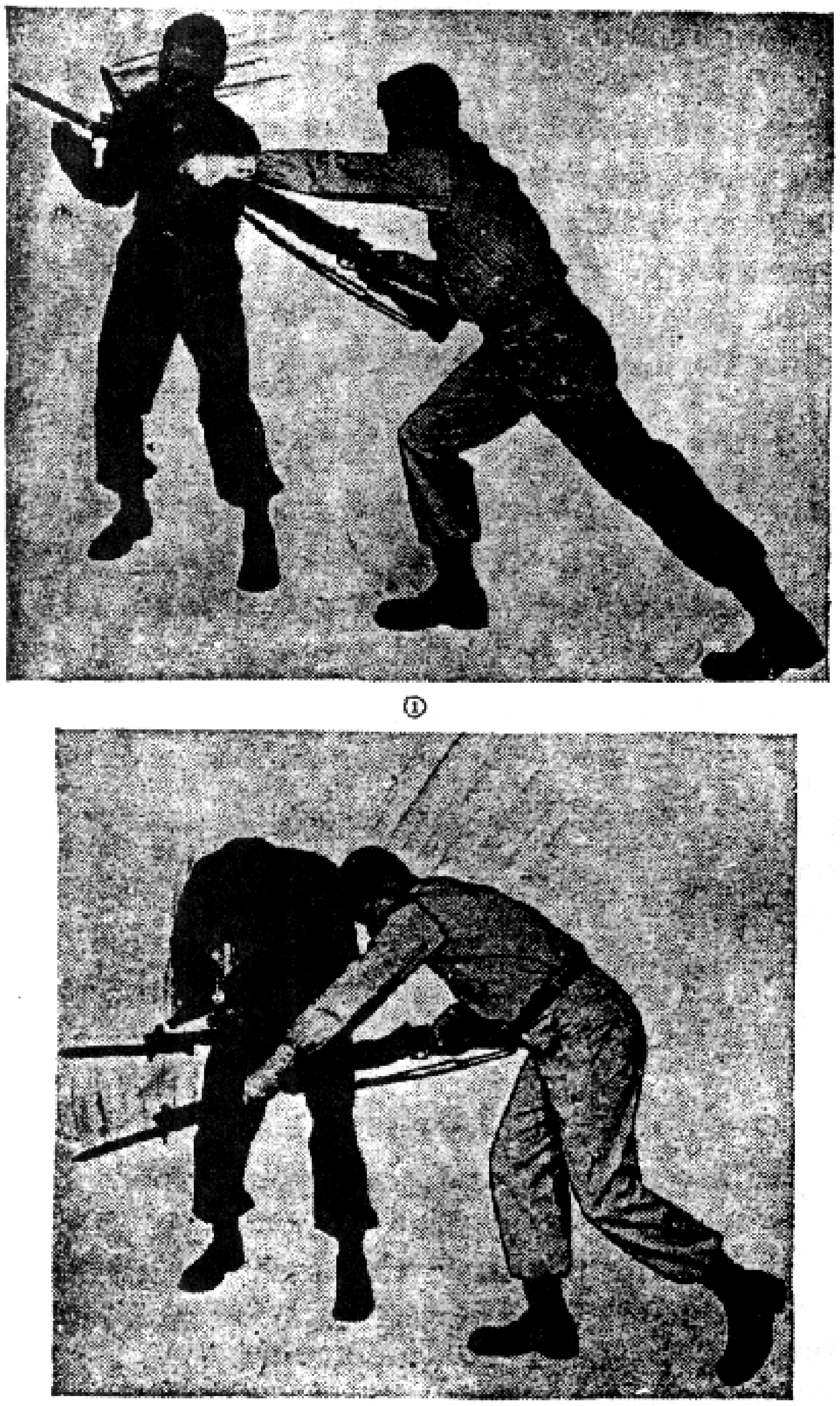
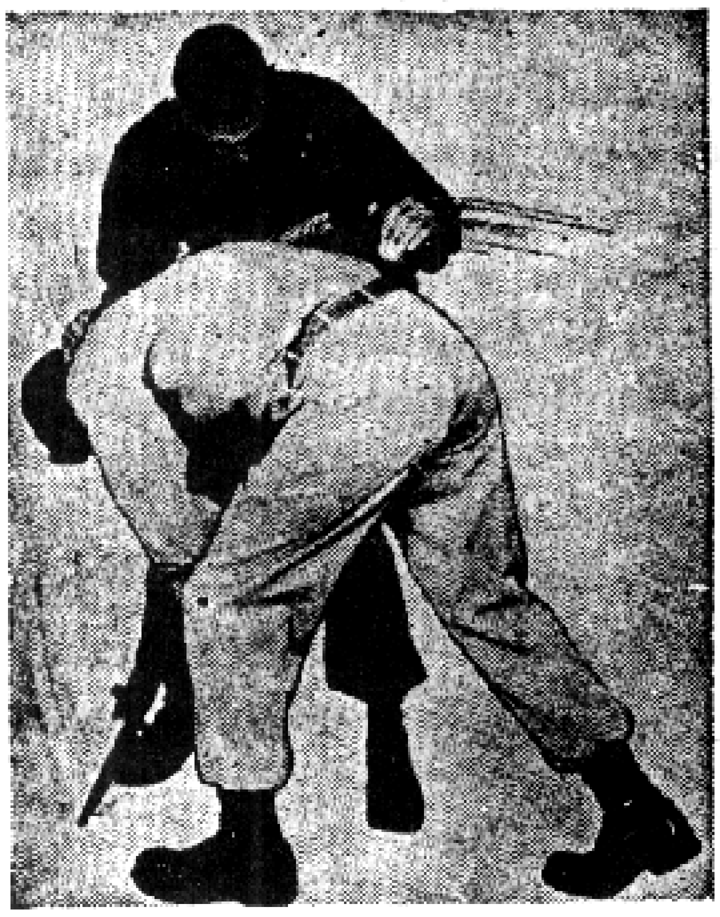


Figure 82. Second counter against long thrust.



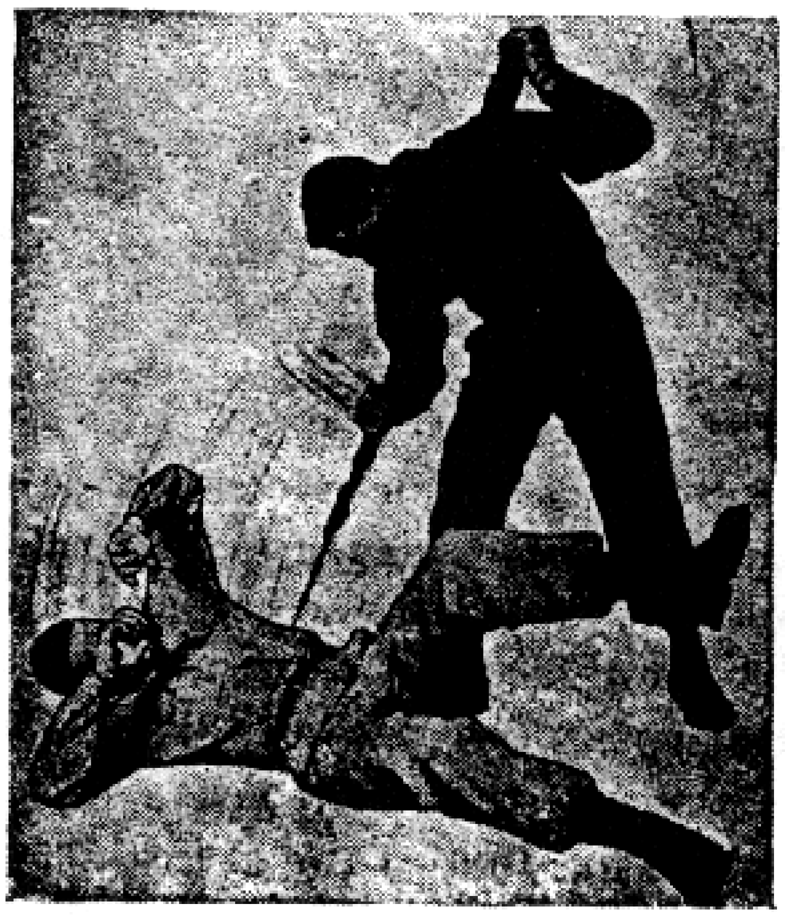


Figure 82. Second counter against long thrust—Continued.

93. Third Counter Against Long Thrust

a. This counter is essentially the same as the method described in paragraph 92 except that you parry left instead of right. This time as you parry, step to your right front with your right foot (fig. 83 ①).

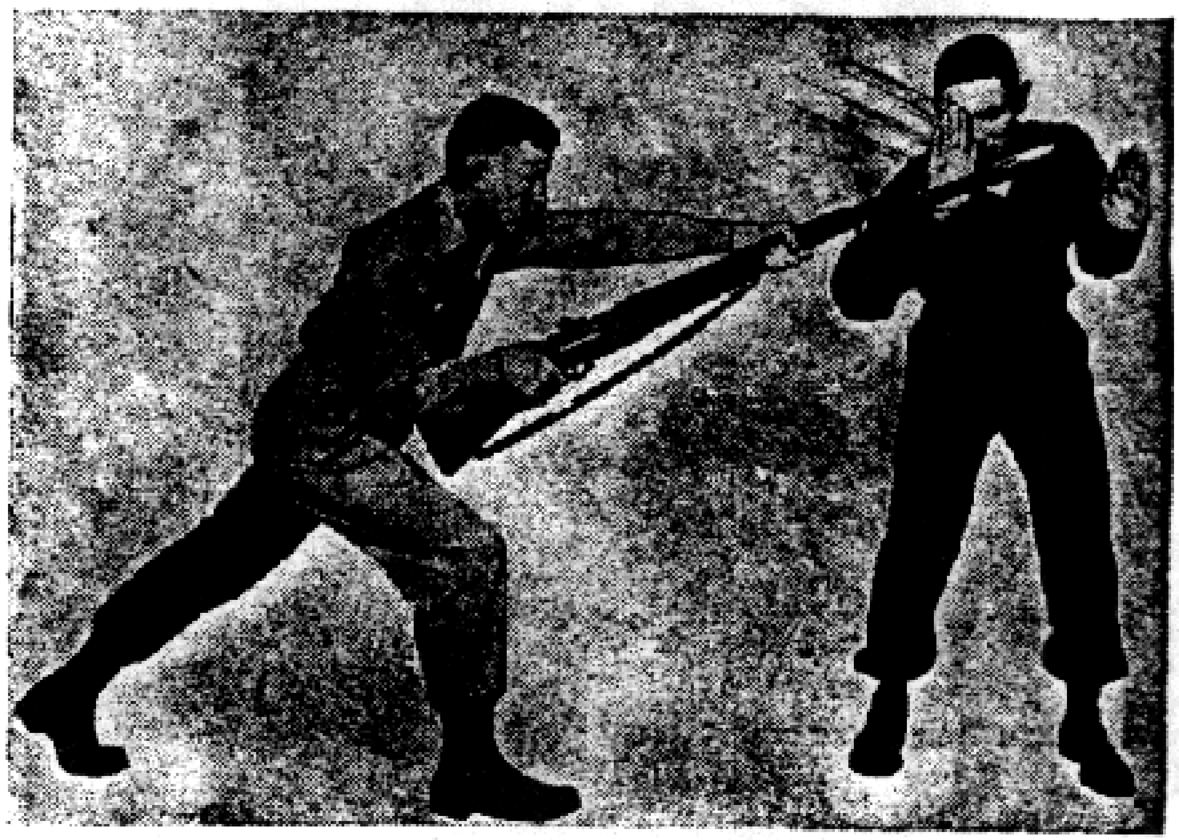


Figure 83. Third counter against long thrust.

b. Execute the same movement as described in paragraph 92*b*. Use the open palms of both hands and drive the bayonet into the ground.

c. It may be difficult to reach across your opponent's body to grasp the butt of the rifle. Therefore, grasp his clothing with both hands and pull him forward, throwing him to the ground (fig. 83 ②).

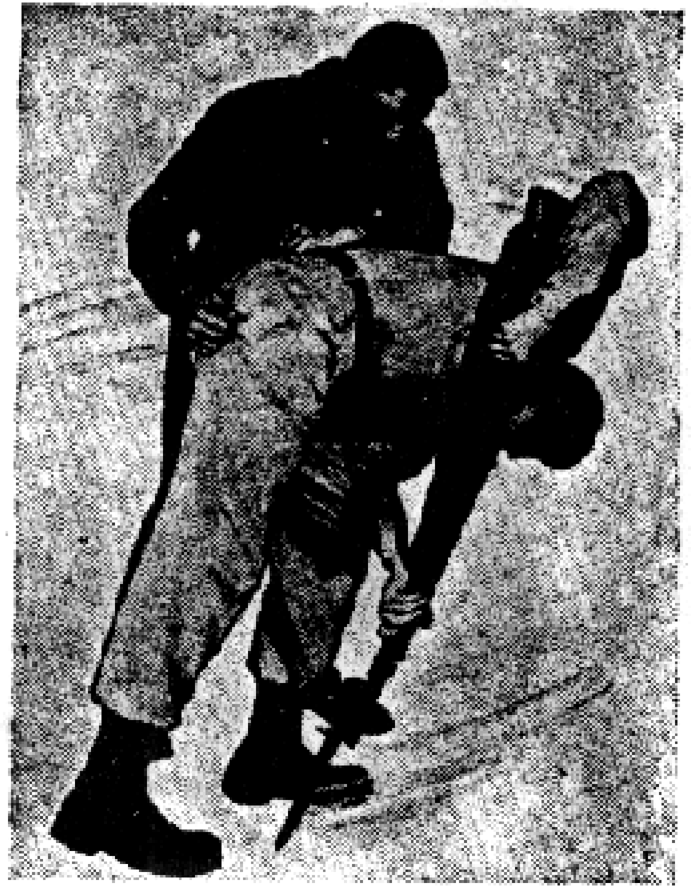


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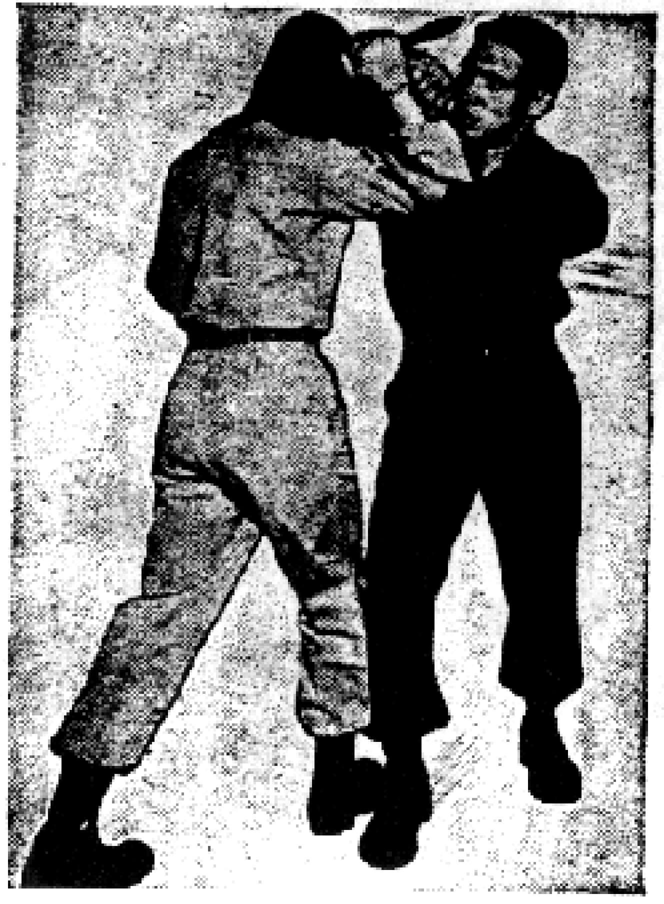
Figure 83. Third counter against long thrust—Continued.

Section II. KNIFE DISARMING

94. Counter Against Downward Stroke

a. If your opponent attacks as shown in figure 84 ①, stop the blow by catching his wrist in the pocket formed by bending your fist forward at your right wrist. Step through with your right foot to protect your groin area. At the same time, strike him sharply in the crook of his right elbow with the thumb side of your forearm or wrist. This causes his arm to bend.

b. Bring your left hand behind his right forearm and underneath your right wrist, and grasp your right forearm. Bring your elbows close to your body (fig. 84 ②).



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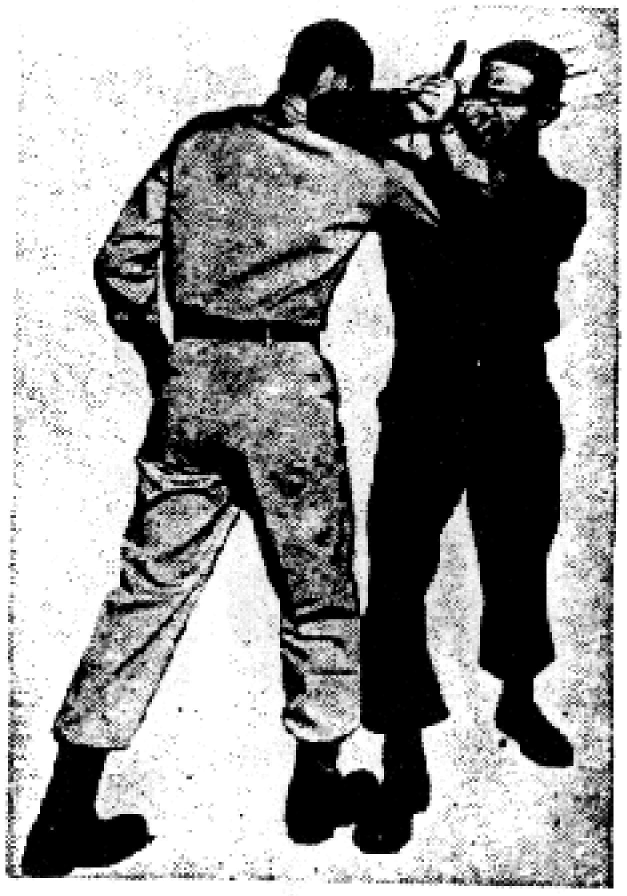

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Figure 84. Counter against downward stroke.

c. Bend swiftly from the waist, putting pressure on your opponent's arm (fig. 84 ③). This causes him to fall backward and lose his weapon.

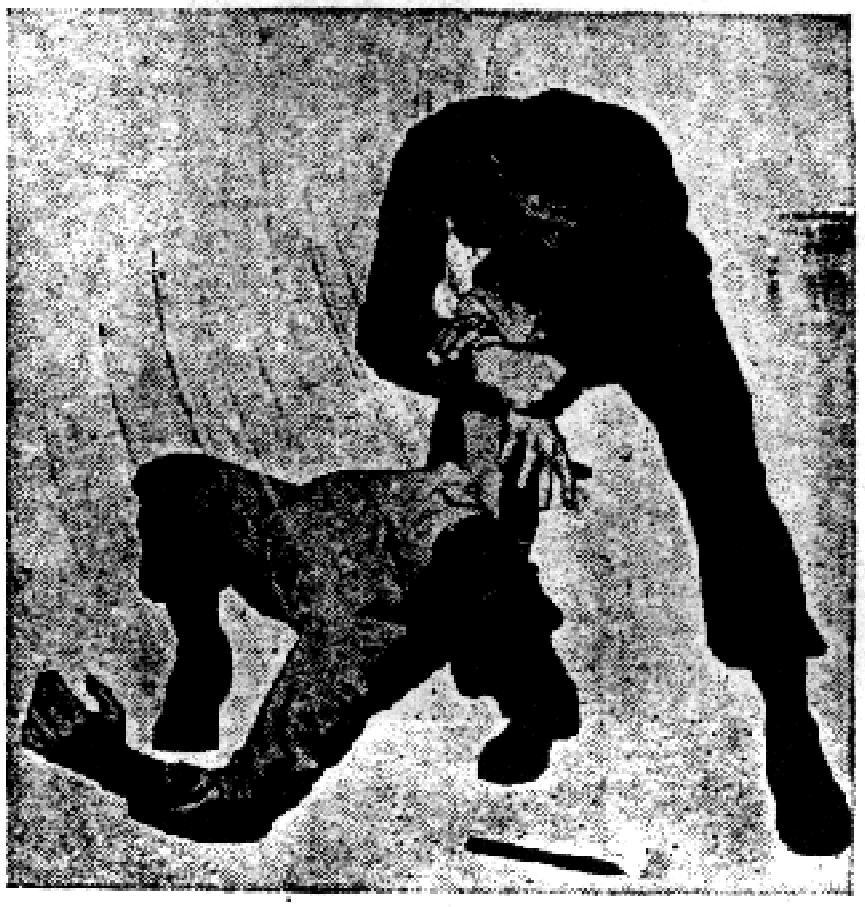

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Figure 84. Counter against downward stroke—Continued.

95. Second Counter Against Downward Stroke

a. Stop the blow by catching your opponent's wrist in the pocket formed at your left wrist by bending your fist forward. Step through with your right foot to protect your groin area. Keep your left forearm horizontal to the ground. At the same time, bring your right hand underneath your opponent's knife arm and grasp your left fist (fig. 85 ①).

b. Bend swiftly forward from the waist and put pressure on your opponent's arm (fig. 85 ②). This causes him to fall backward and lose his weapon.

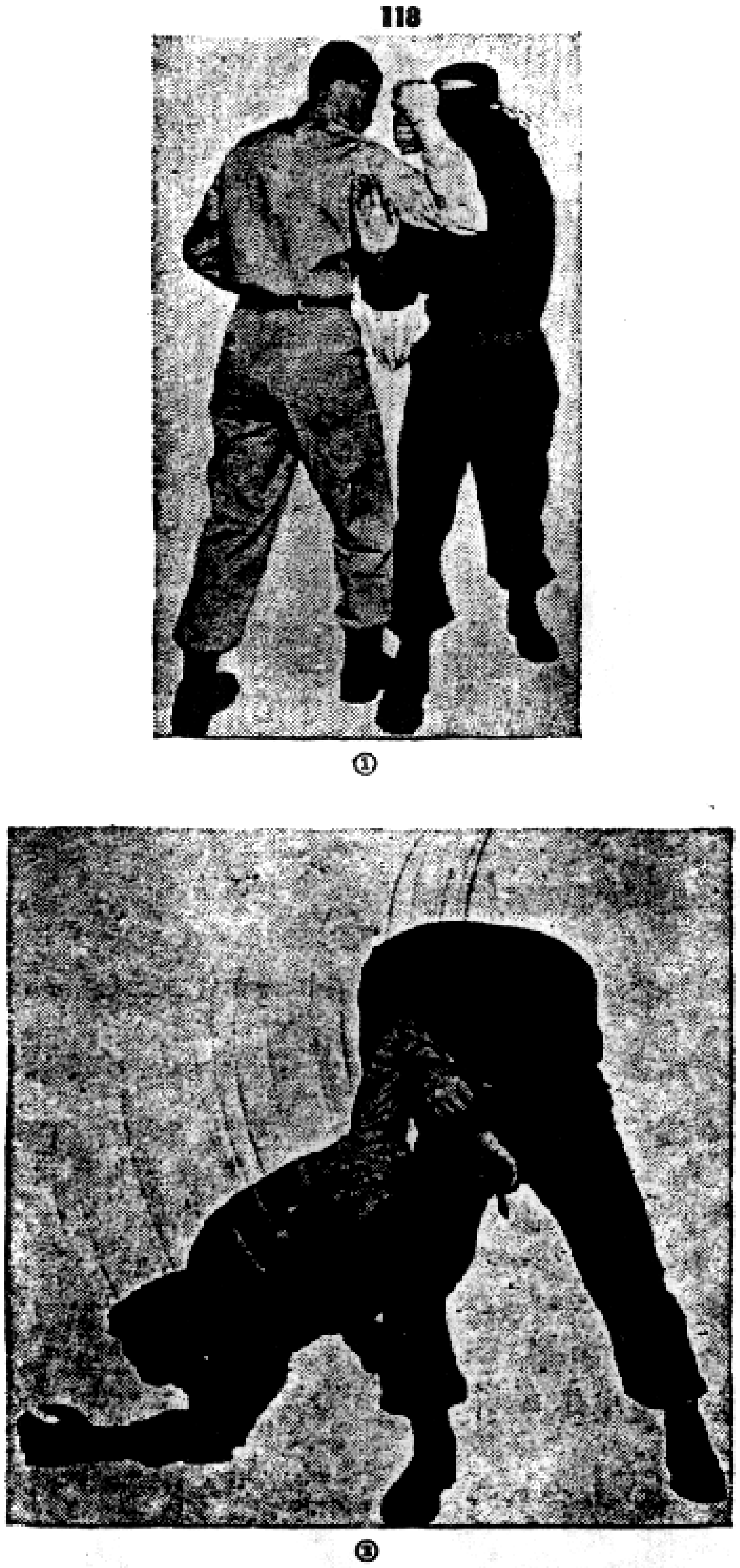

Figure 85. Second counter against downward stroke.

96. Counter Against Upward Stroke

a. Block an upward knife stroke by catching your opponent's wrist or forearm in the pocket formed at your left wrist by bending your fist forward. Keep your elbow low. At the same time, twist your body to the right (fig. 86 ①).

b. As soon as you stop the blow, grasp your attacker's right hand with your right hand and place your thumb on the back of his hand. Reinforce this hold by grasping his wrist with your left hand and placing your left thumb on the back of his hand (fig. 86 ②).

c. Twist his wrist to your left and bend his hand toward his forearm, causing him to fall to the ground (fig. 86 ③).

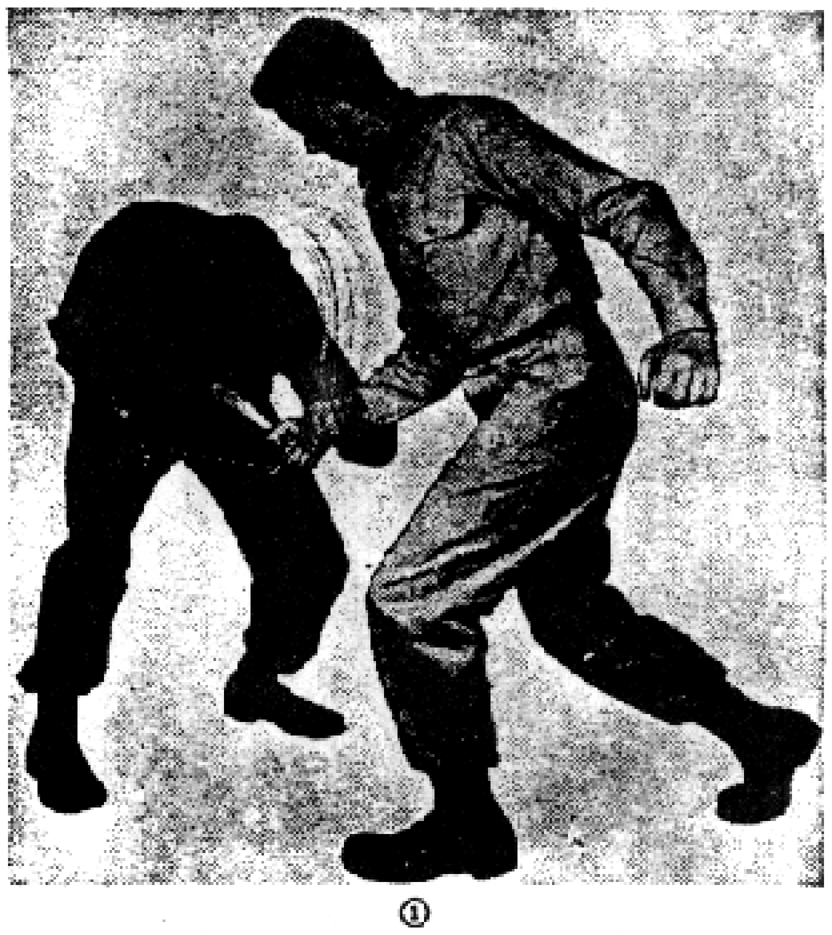

Figure 86. Counter against upward stroke.

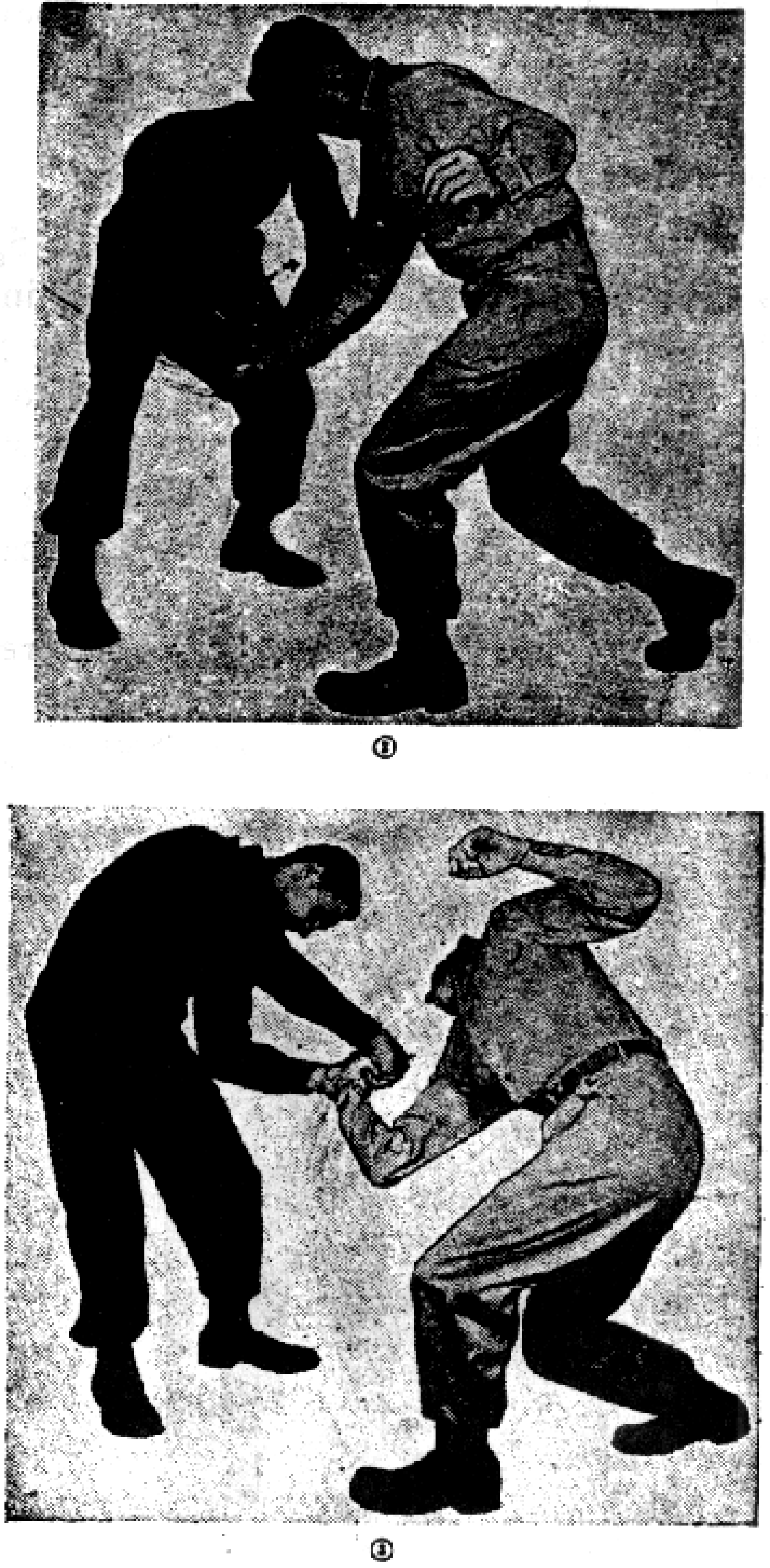

Figure 86. Counter against upward stroke—Continued.

97. Second Counter Against Upward Stroke

a. Another method of defending yourself against an upward stroke is to block your opponent's wrist or forearm in a "V" formed by your hands (fig. 87 ①). Keep your arms extended. Take a short crowhop to the rear as you block his thrust so your midsection is further from the point of the knife (fig. 78 ②).

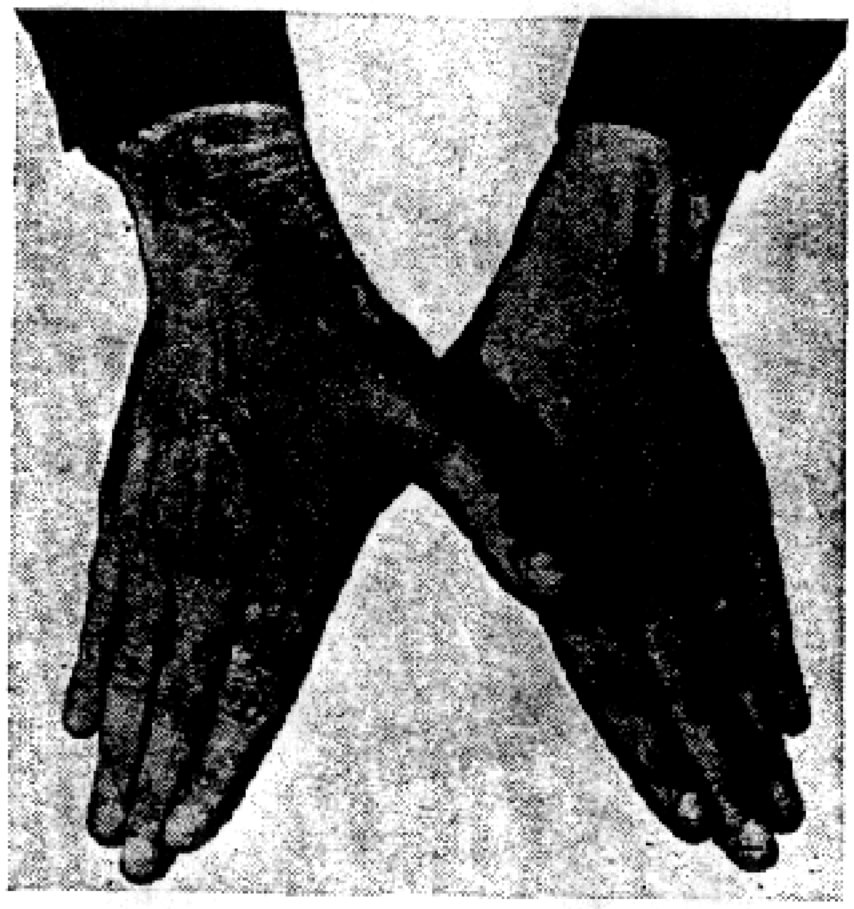

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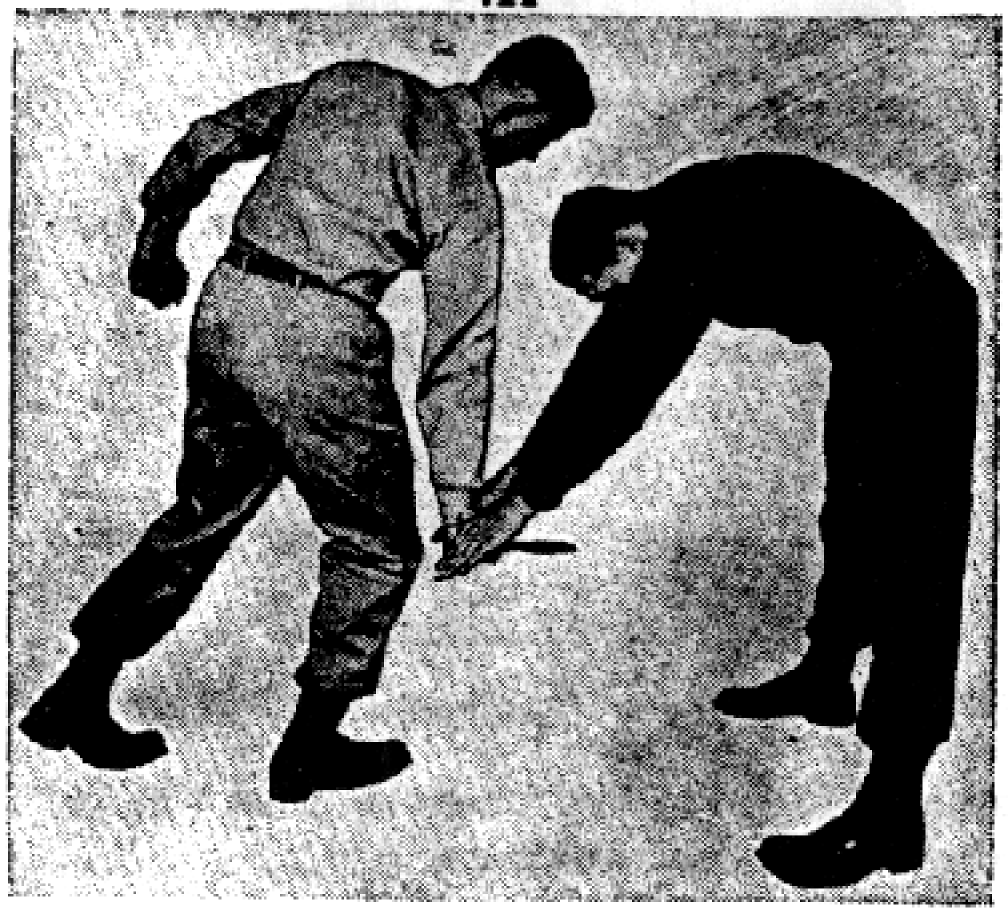
Figure 87. Second counter against upward stroke.

b. Grasp your opponent's wrist tightly with both hands and pivot to your left on the ball of your left foot. At the same time, raise your opponent's knife hand and step directly beneath his arm (fig. 87 ③). From this position, snap his arm forward and downward, bending at the waist and, at the same time, drive him to the ground with a whipping action (fig. 87 ④).



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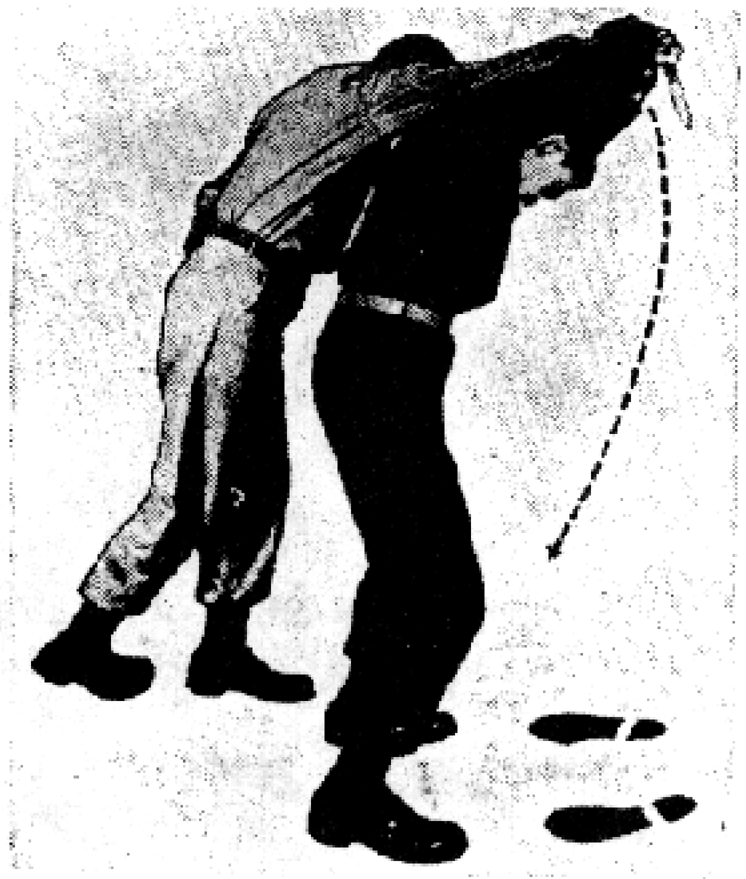

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Figure 87. Second counter against upward stroke—Continued.

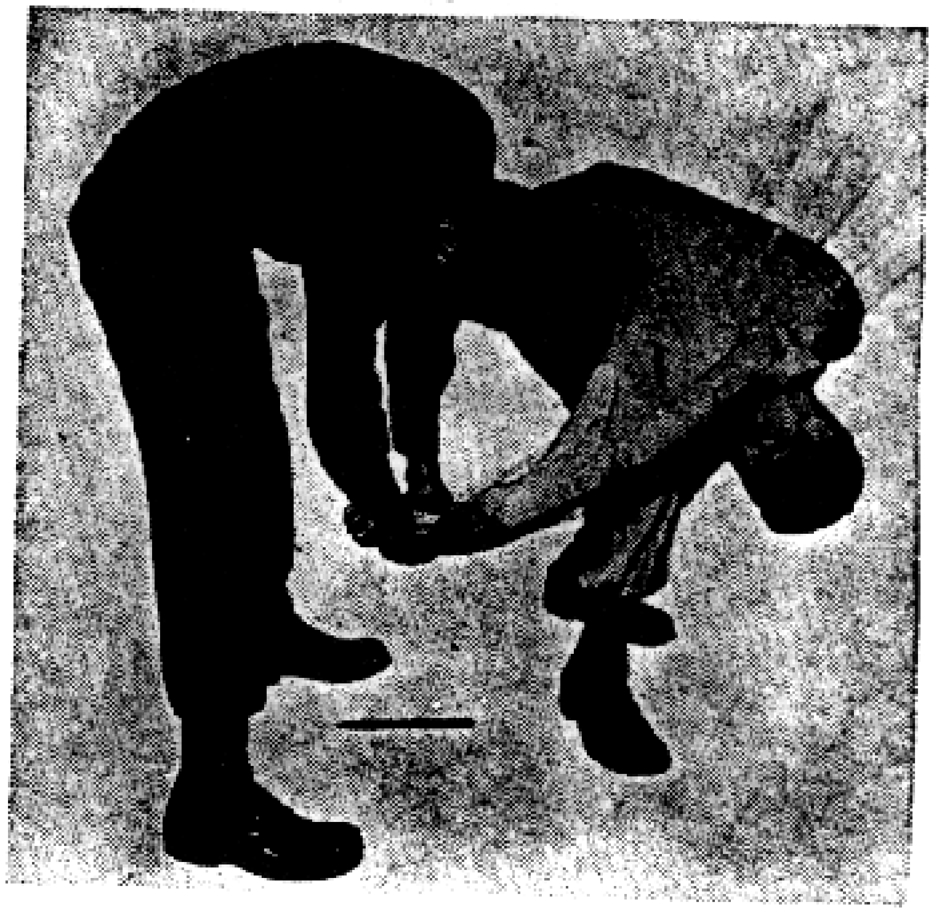

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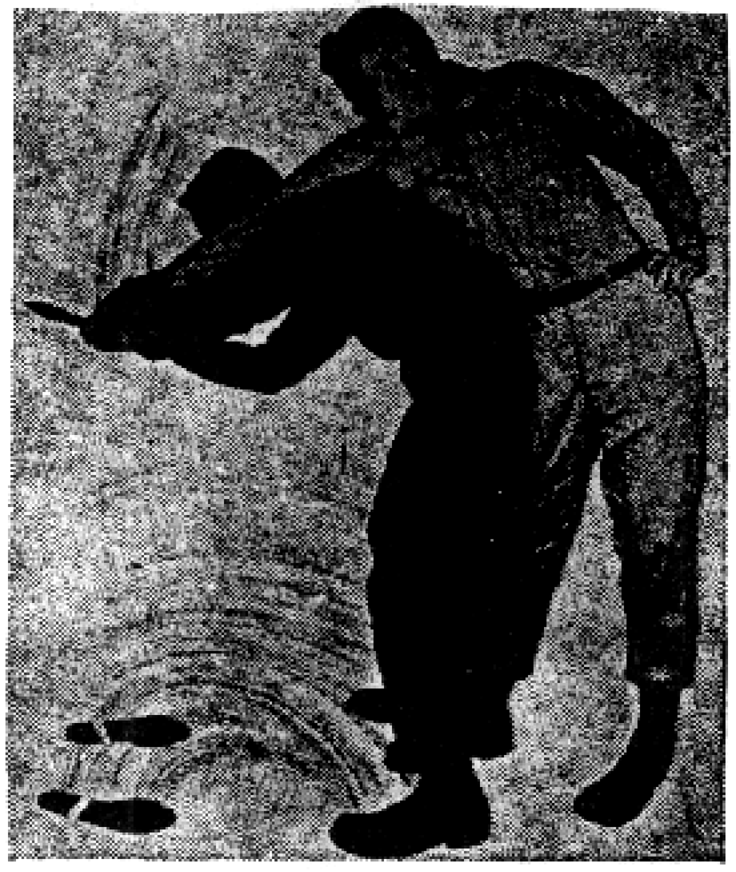
Figure 87. Second counter against upward stroke—Continued

98. Third Counter Against Upward Stroke

a. This phase is the same as that described in paragraph 97*a.*

b. Grasp your opponent's wrist tightly with both hands and pivot to your right. Raise his hand and bring his arm down over your left shoulder (fig. 88 ①).

c. Apply downward pressure on his arm. This will throw him to the ground or break his arm. This method can be varied by stepping completely under his arm and behind his back and forcing him to drop the knife by bending his arm (fig. 88 ②). You must pivot quickly to prevent him from spinning out of the hold.



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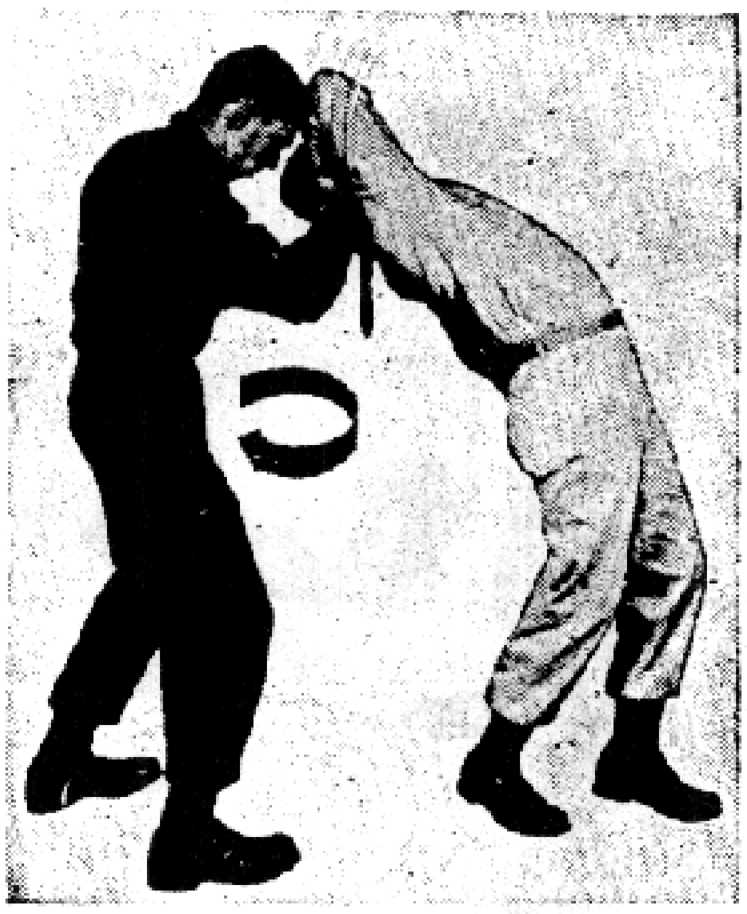

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Figure 88. Third counter against upward stroke.

99. Counter Against Backhand Slash

a. To defend yourself against a backhand slash with a knife, bend your knees and lower your body without ducking your head. At the same time, raise your right arm and block your opponent's thrust with your forearm or wrist (fig. 89 ①).

b. As soon as you block the blow, grasp your opponent's knife hand with your left hand, your thumb in the center of the back of his hand. Apply pressure with your right wrist against his right wrist or forearm. Start to twist the knife hand to your left (fig. 89 ②), then reinforce your left-hand hold with a similar hold with your right hand. Both your thumbs are in the center of the back of his hand and your fingers are around his palm (fig. 89 ③). A twist to your left or pressure that bends your opponent's hand forward and under against his wrist causes him to lose his weapon and, in many cases, to suffer a broken or dislocated wrist.

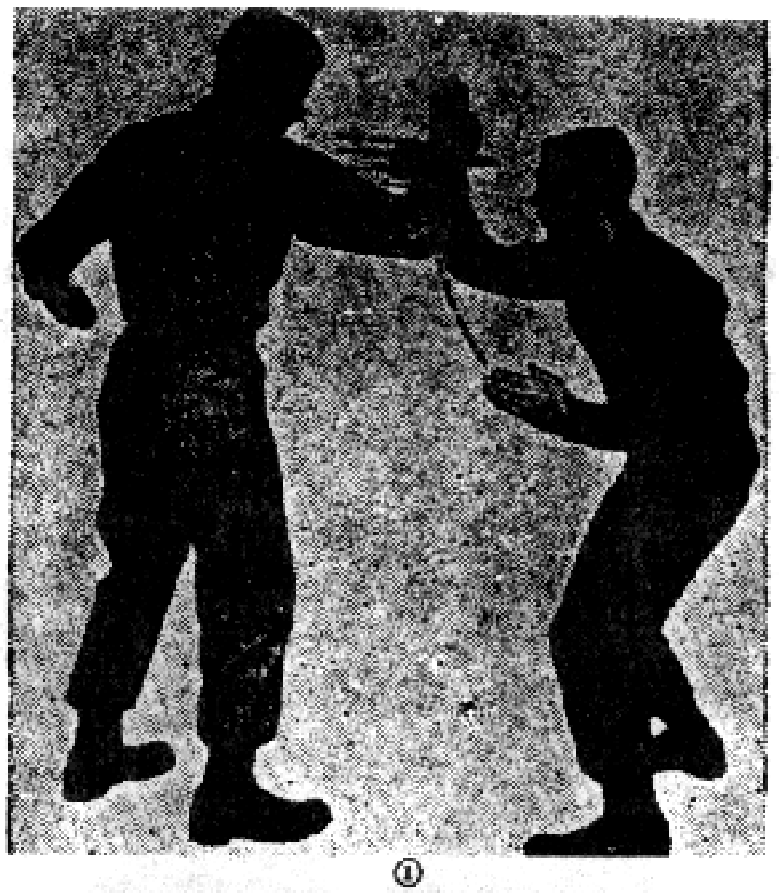

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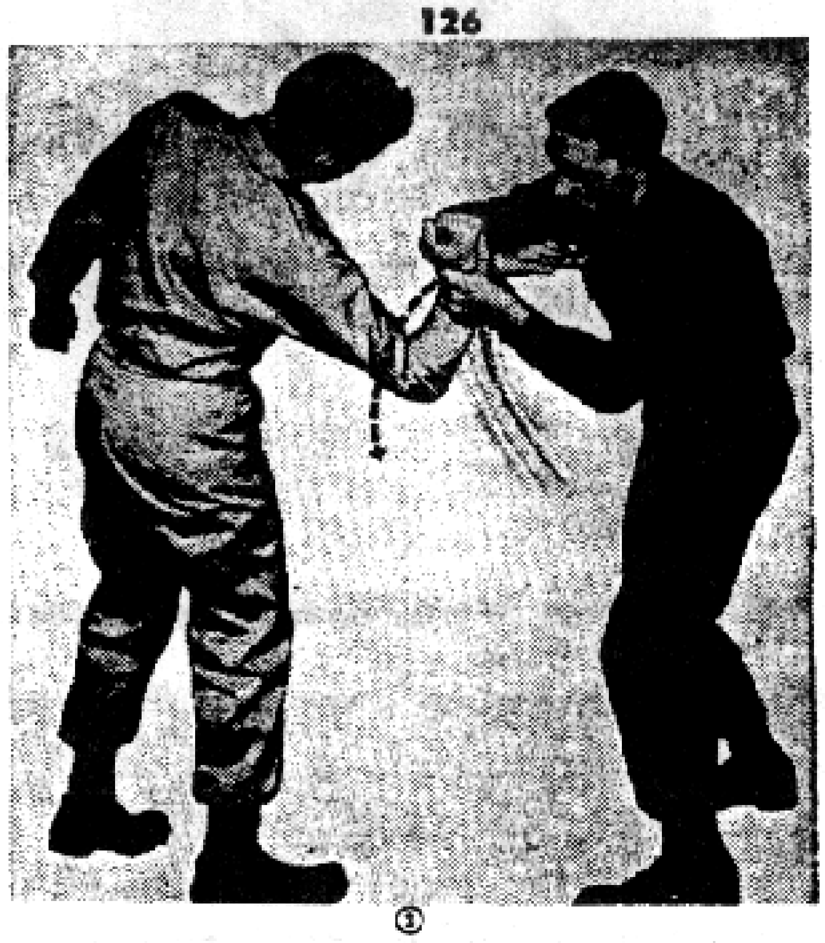
Figure 89. Counter against backhand slash.



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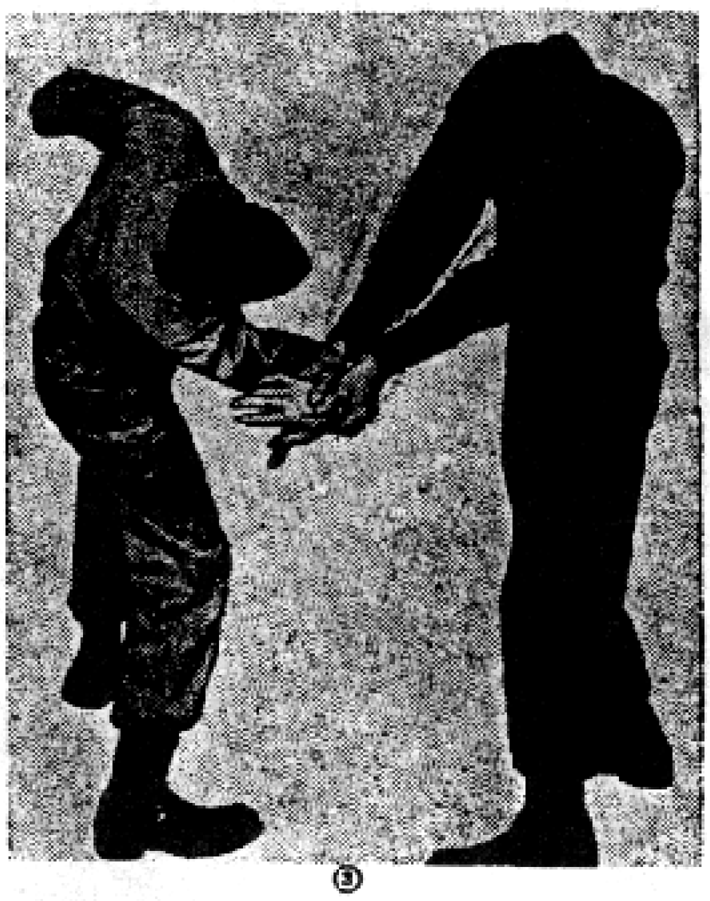

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Figure 89. Counter against backhand slash—Continued.

100. Counter Against a Cautious Approach

When your opponent attacks as shown in figure 90 ①, his left foot is forward and his left hand is extended to ward off any of your possible blows. He holds his knife hand close to his right hip, ready to strike when an opening occurs. This is an extremely dangerous man. He is well-prepared and well-trained and your actions must be perfect. As soon as he comes within reach, spring from the ground, throwing your body at him feet first and twisting to your left. Hook your left instep around his forward ankle and kick his knee with your right foot (fig. 90 ②). Break the force of your fall with your hand or arm. This motion drops him on his back. When both of you strike the ground, raise your right foot and kick his groin or midsection (fig. 90 ③).

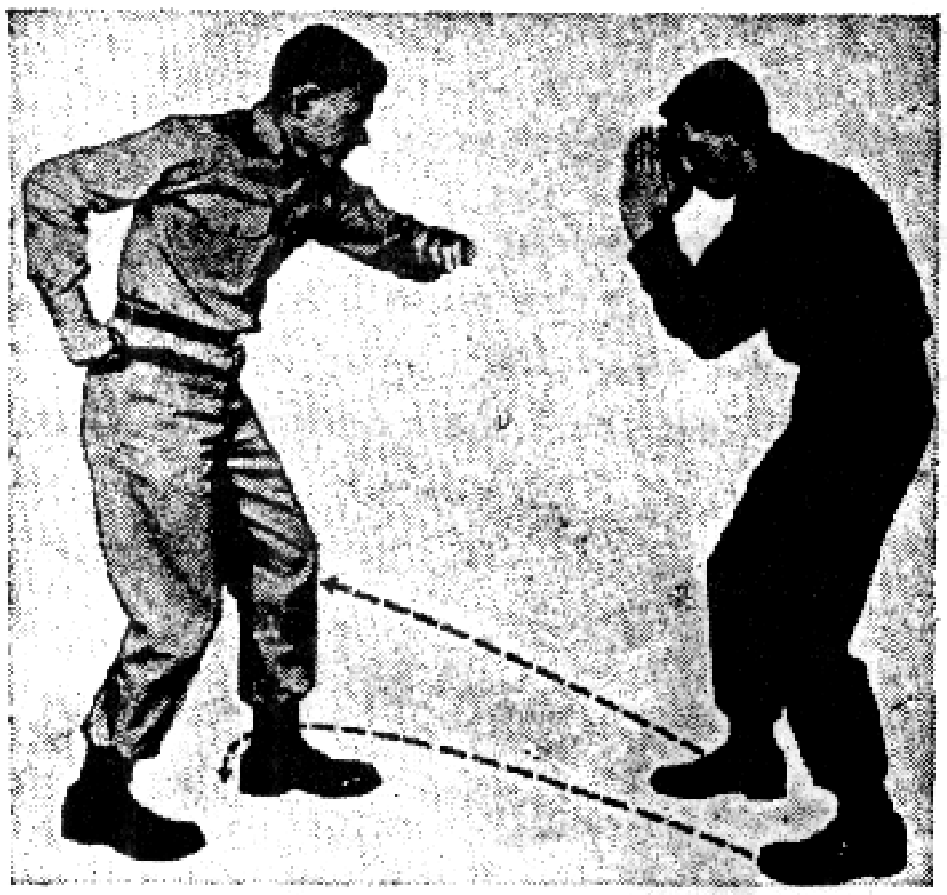
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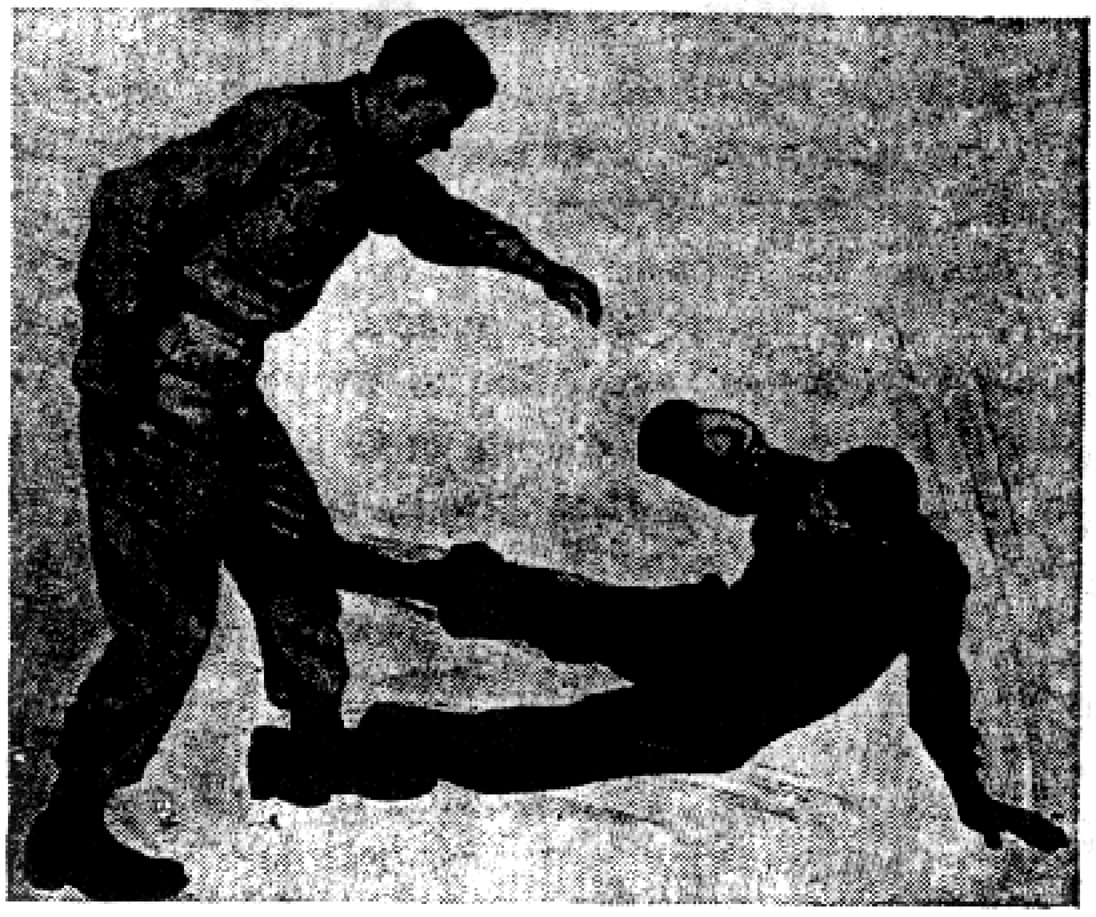
Figure 90. Counter against a cautious approach.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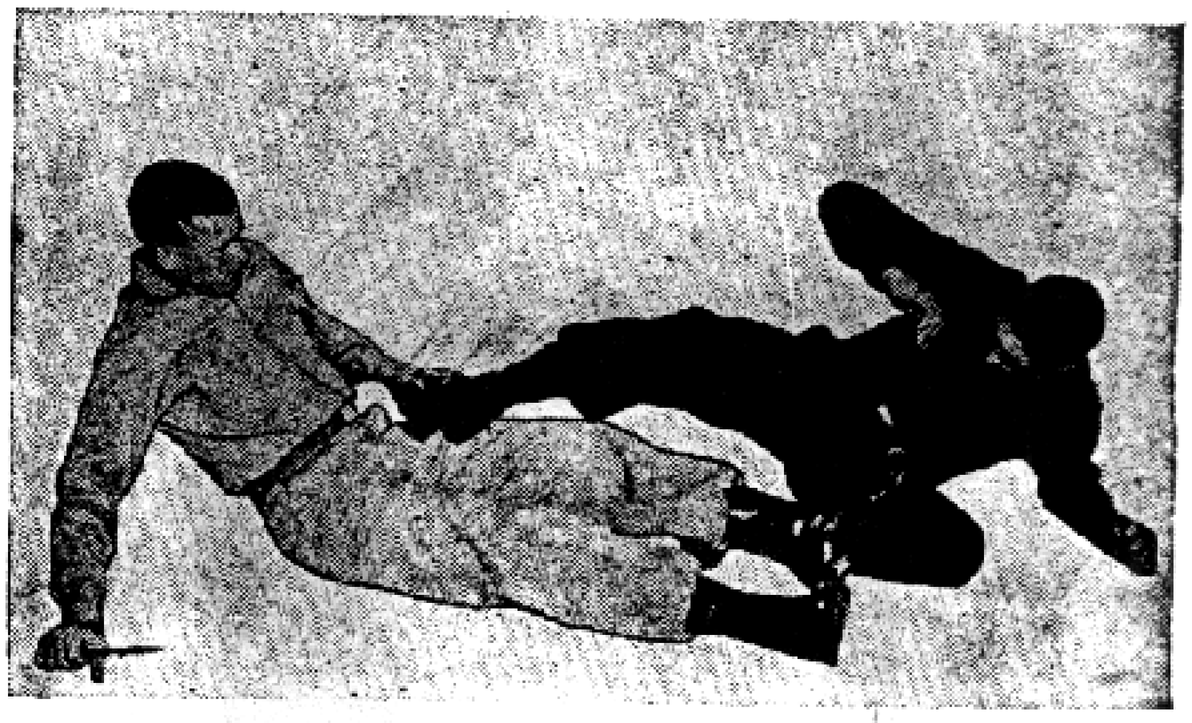
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Figure 90. Counter against a cautious approach—Continued

Section III. RIFLE DISARMING

101. Speed in Disarming

When disarming an opponent armed with a rifle or pistol, make each movement quickly and without hesitation. Although your opponent has the weapon, you are in a good position because you know what you are going to do whereas he has to react to your movement. *Although his reaction time is short, it is not as short as the time it takes you to act.*

102. Counter Against Rifle in Front

a. Figure 91 ① illustrates the holdup. At your opponent's order of "hands up," bring your hands to shoulder level. Then, in one motion, twist your body to your right and strike the muzzle of the rifle away

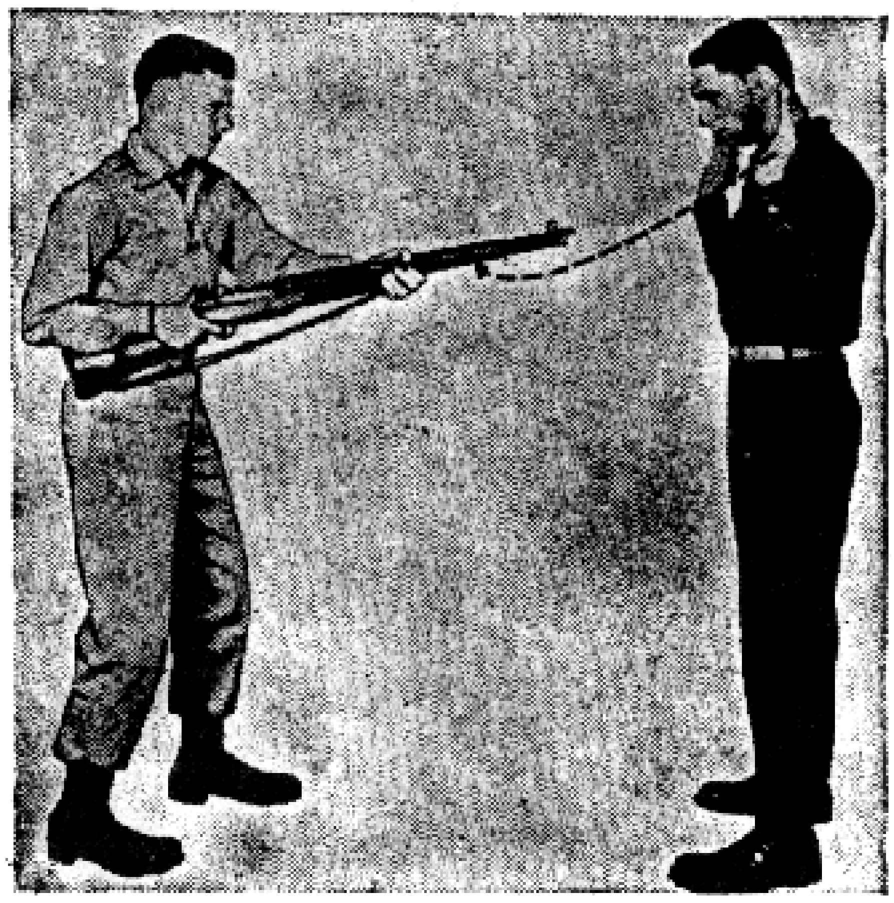
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Figure 91. Counter against rifle in front.

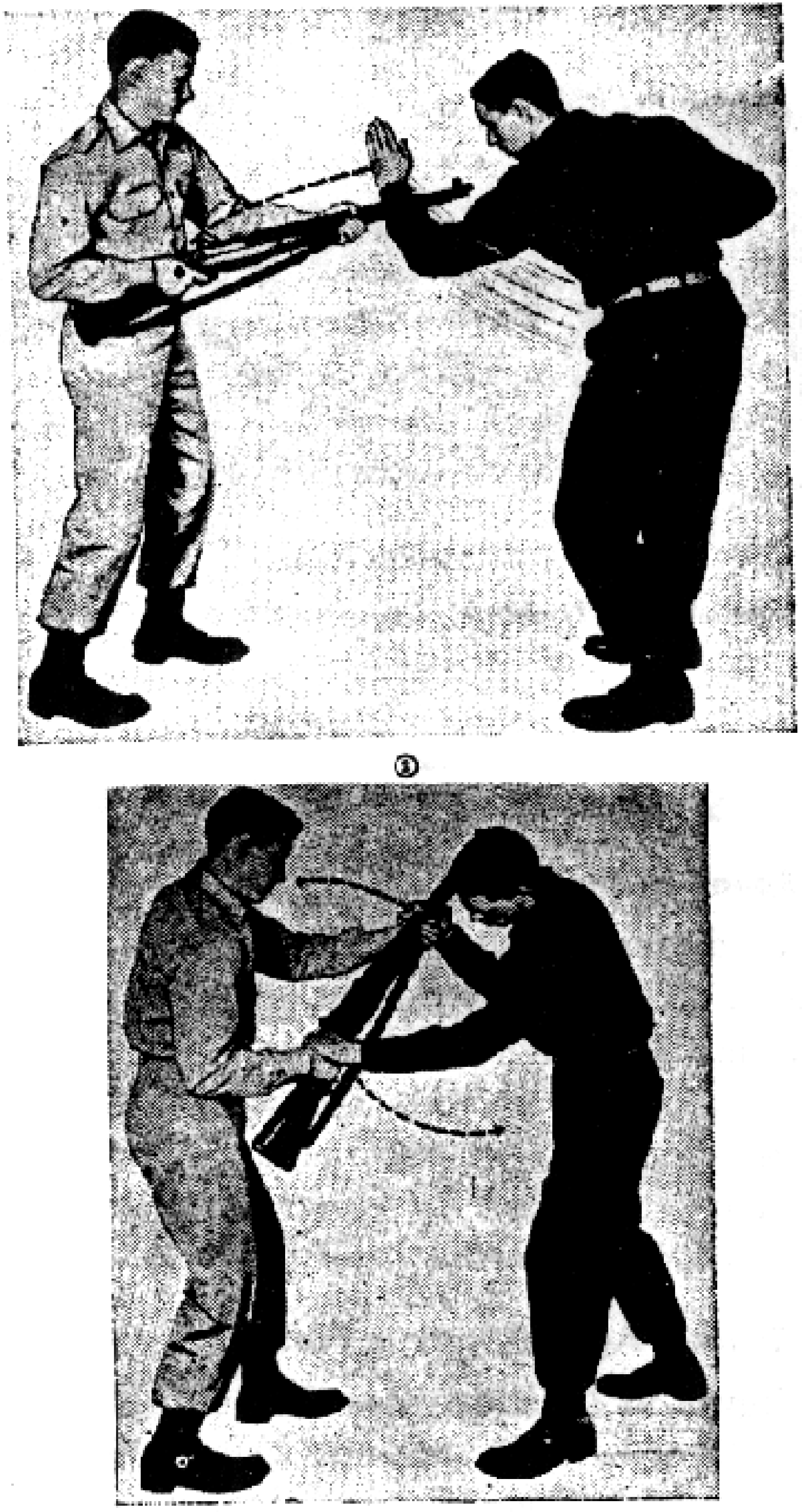


Figure 91. Countei ugainst rifle in front—Continued

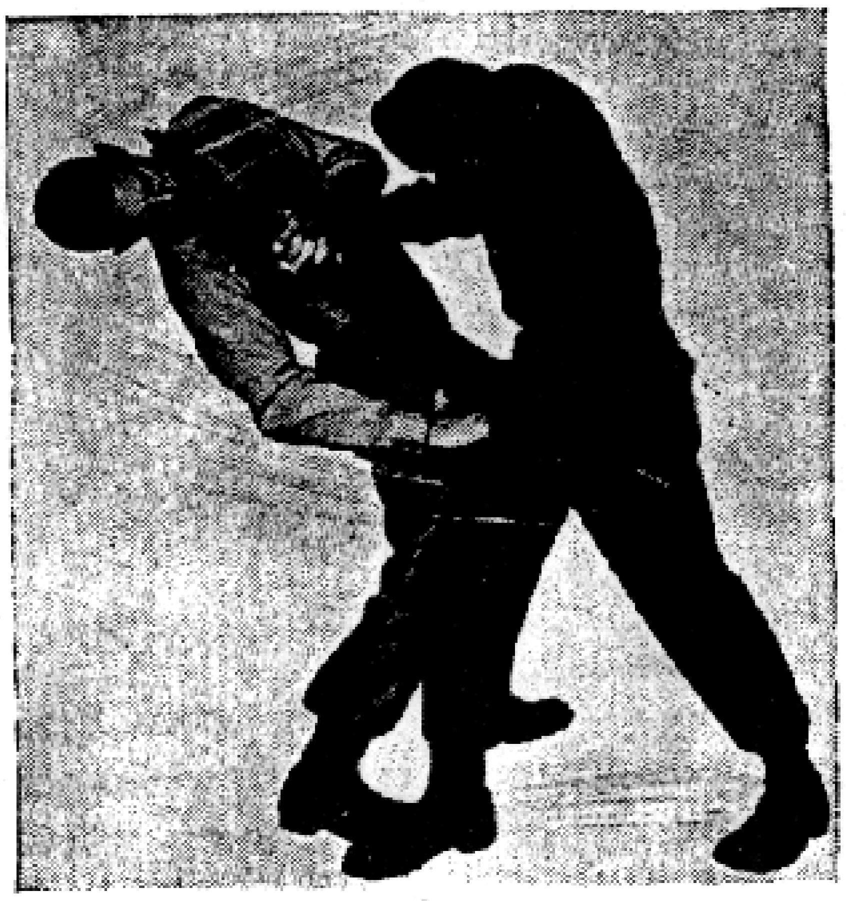


Figure 91. Counter against rifle in front—Continued

from your body with your left forearm or wrist (fig. 91 ②).

b. As you strike the muzzle, step forward with your left foot and grasp the upper handguard with your right hand and the small of the stock with your left hand (fig. 91 ③).

c. Pull with your left hand and push with your right and step to your opponent's right with your own right foot. This knocks him off balance and, at the same time, enables you to strike him on the head with the muzzle of the rifle or to take the rifle from him by twisting it over his right shoulder (fig. 91 ④).

103. Counter Against Rifle in Back

a. When your opponent has his rifle in your back as shown in figure 92 ①, start to elevate your hands as ordered. When your hands reach shoulder height, twist from the hips to your right and bring your right elbow back, striking the muzzle of the rifle. This deflects the rifle away from your body. Do not as yet move your feet from their original position (fig. 92 ②).

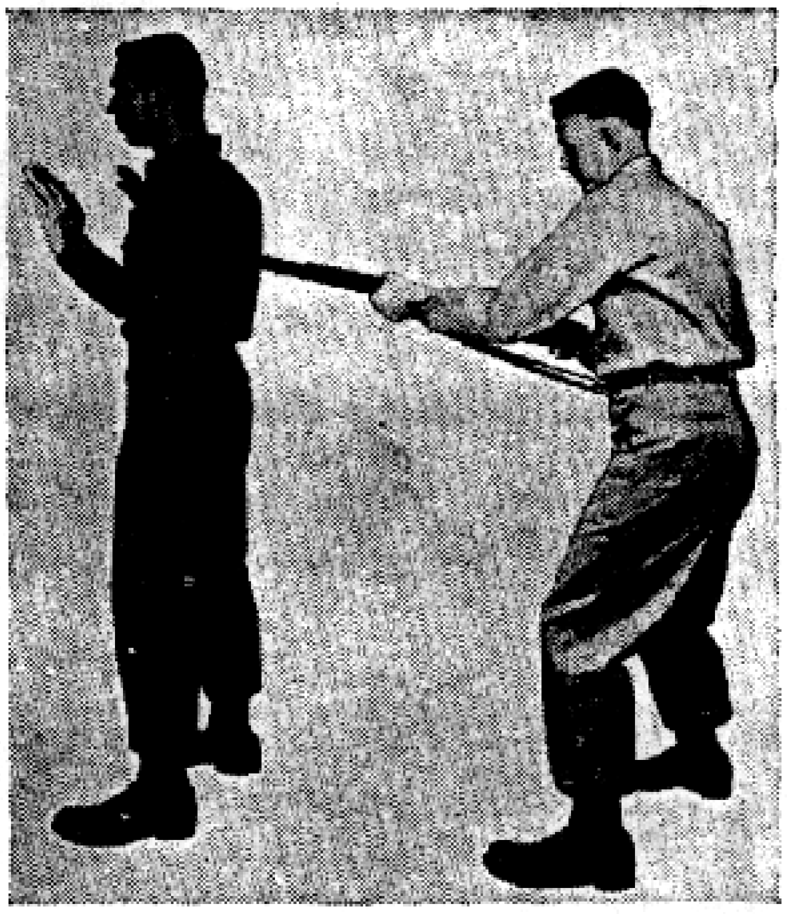
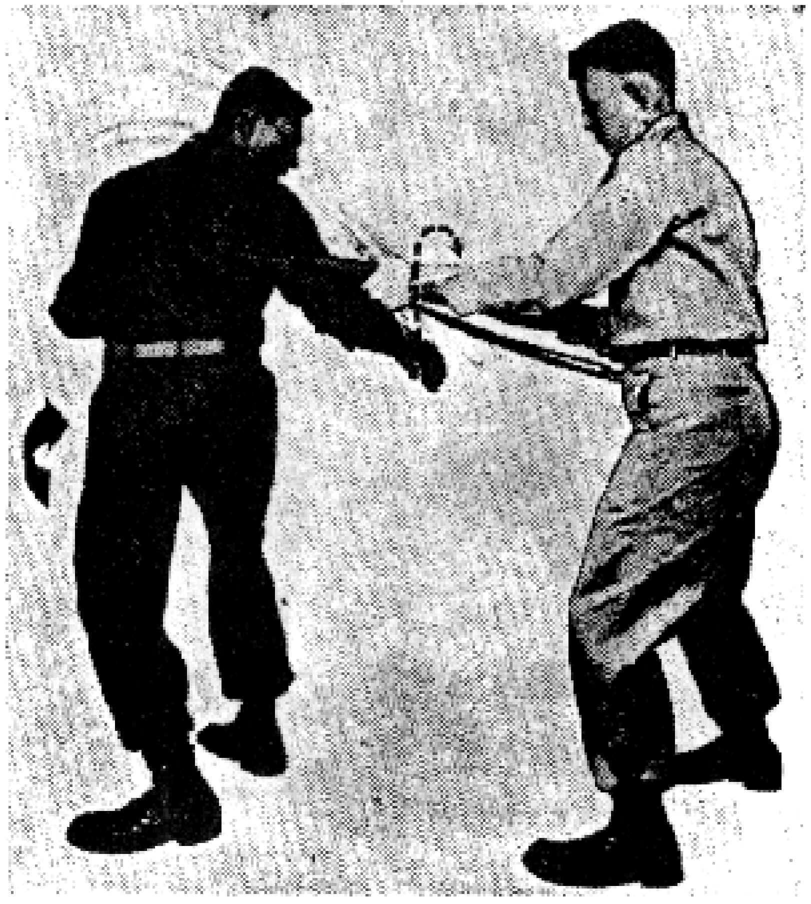


Figure 92. Counter against rifle in back.

b. Turn to the right by pivoting on your right foot. Face your opponent and bring your right arm under the rifle and over your opponent's left wrist. Place your left hand on your opponent's right hand where it grasps the stock (fig. 92 ③). This prevents him from executing a butt stroke.

c. Pull with your left hand and push with your right shoulder and arm, forcing your opponent to the ground and making him release his grip on the rifle (fig. 92 ④).



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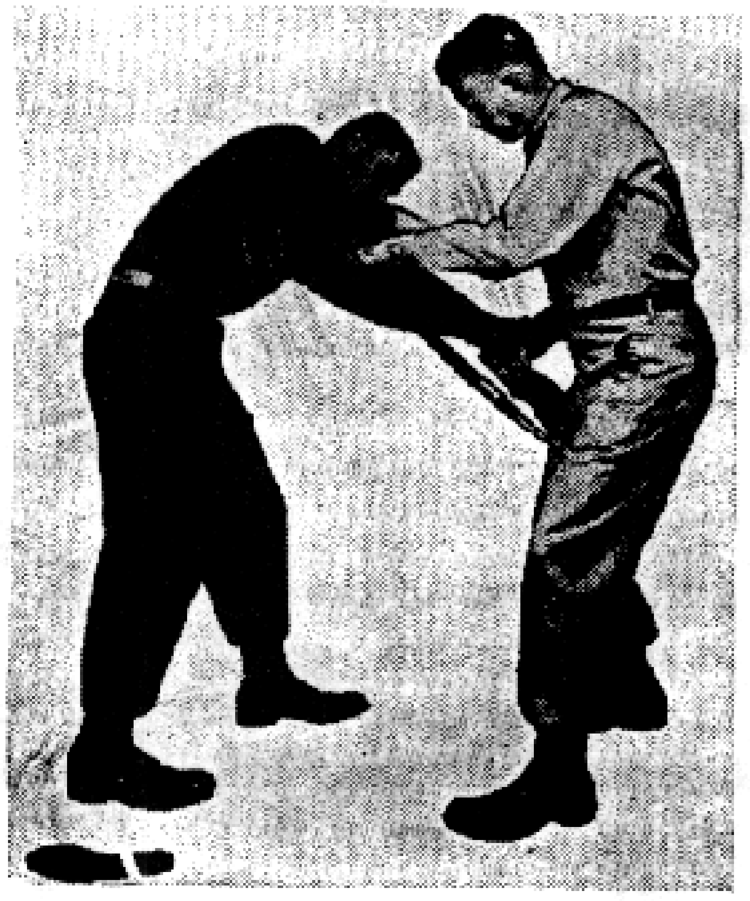

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Figure 92. Counter against rifle in back—Continued

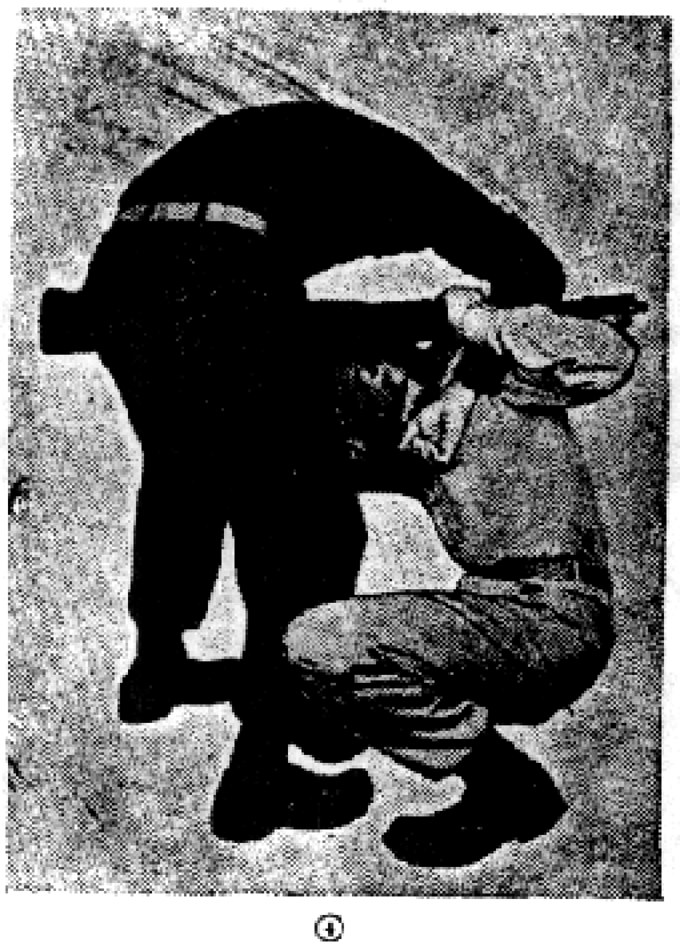

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Figure 92. Counter against rifle in back—Continued

Section IV. PISTOL DISARMING

104. Counter Against Pistol in Front

a. Your opponent orders you to raise your hands. As you do so, keep your elbows as low as possible (fig. 93 ①). Twist your body to the right and strike your opponent's wrist with your left forearm (fig. 93 ②).

b. Grasp the bottom of the barrel with your right hand, making certain that your hand is not near the muzzle. At the same time, strike downward on your opponent's wrist with your left fist (fig. 93 ③). While applying pressure with your left fist, bend the pistol towards your opponent's body with your right hand, causing him to release his grip (fig. 93 ④). If he should retain his grip, his index finger will be broken. From this position, you can strike your opponent on his temple with the butt of the pistol.

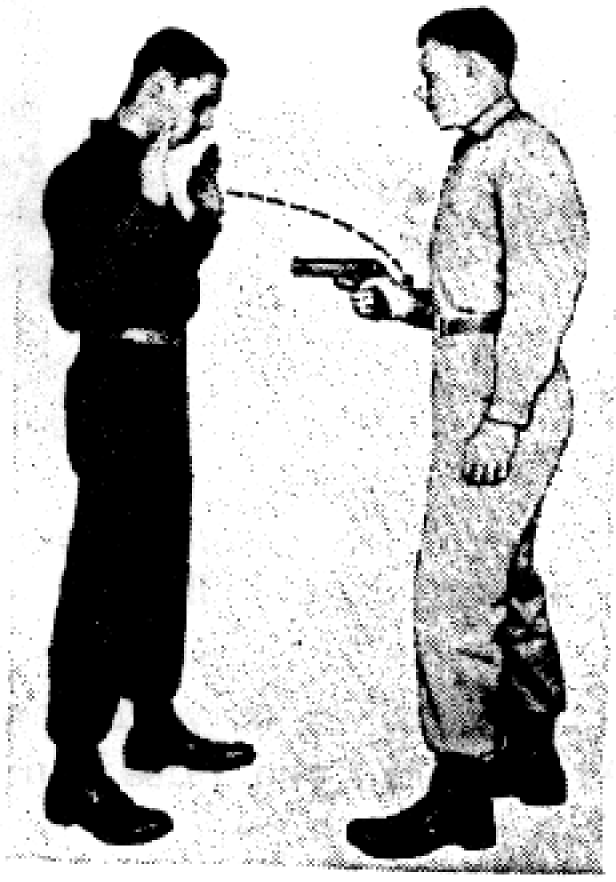

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Figure 93. Counter against pistol in front.

105. Second Counter Against Pistol in Front

As you begin to raise your hands, bring them quickly forward and, at the same time, twist to your left away from the line of fire (fig. 94 ①). Bring your right hand under your opponent's wrist either with a grasping or a striking motion and, simultaneously, grasp the barrel of the pistol with your left hand (fig. 94 ②). Push up on the wrist with your right hand and down and out on the pistol with your left hand (fig. 94 ③). Your opponent will release his grip.

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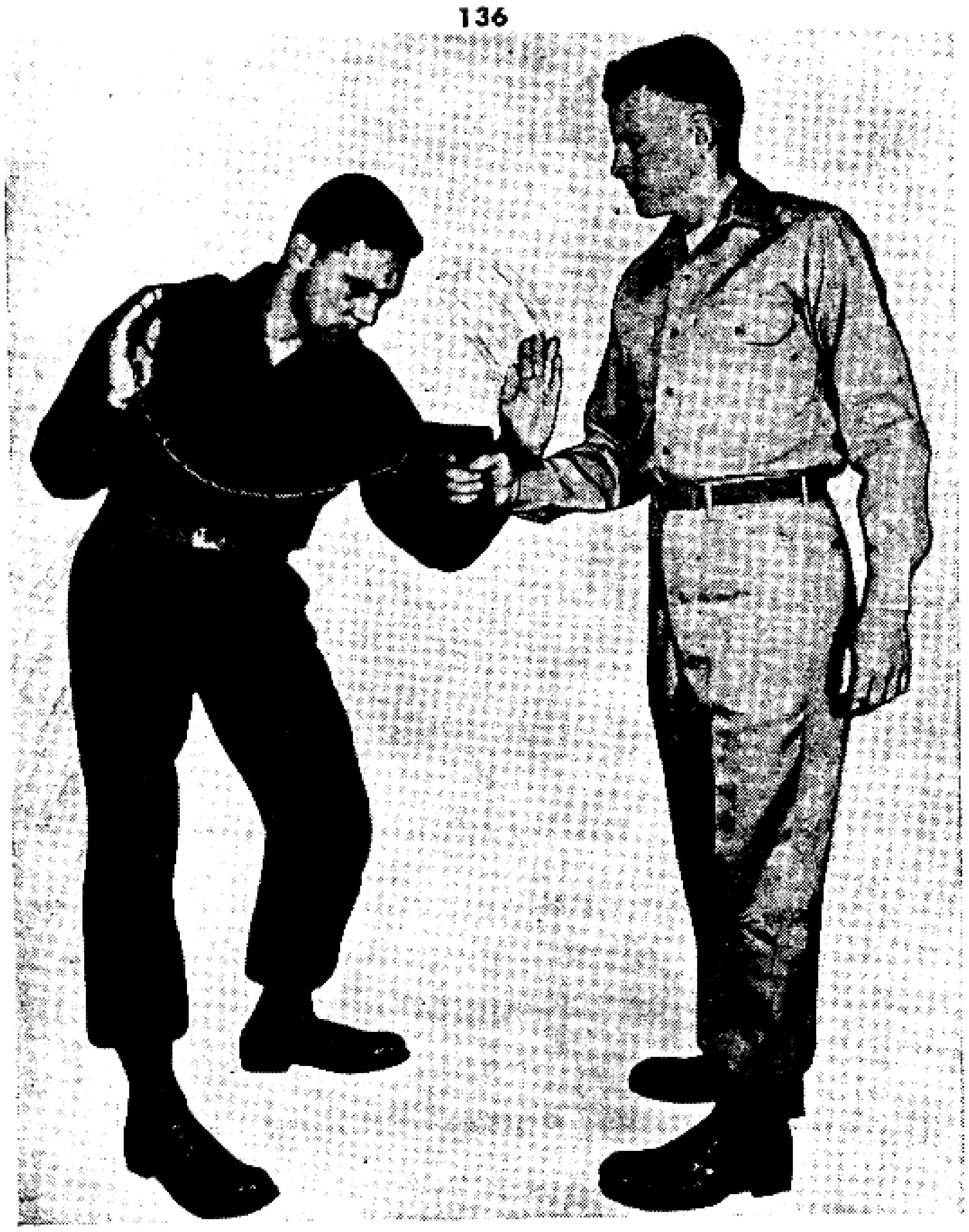

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Figure 93. Counter against pistol in front—Continued

106. Counter Against Pistol in Back

a. This counter should be used only when you are certain that the pistol is in your opponent's right hand (fig. 95 ①). As you raise your hands, keep your elbows as close to the waist as possible. Twist your body to the right and, at the same time, bring your right elbow against your opponent's forearm

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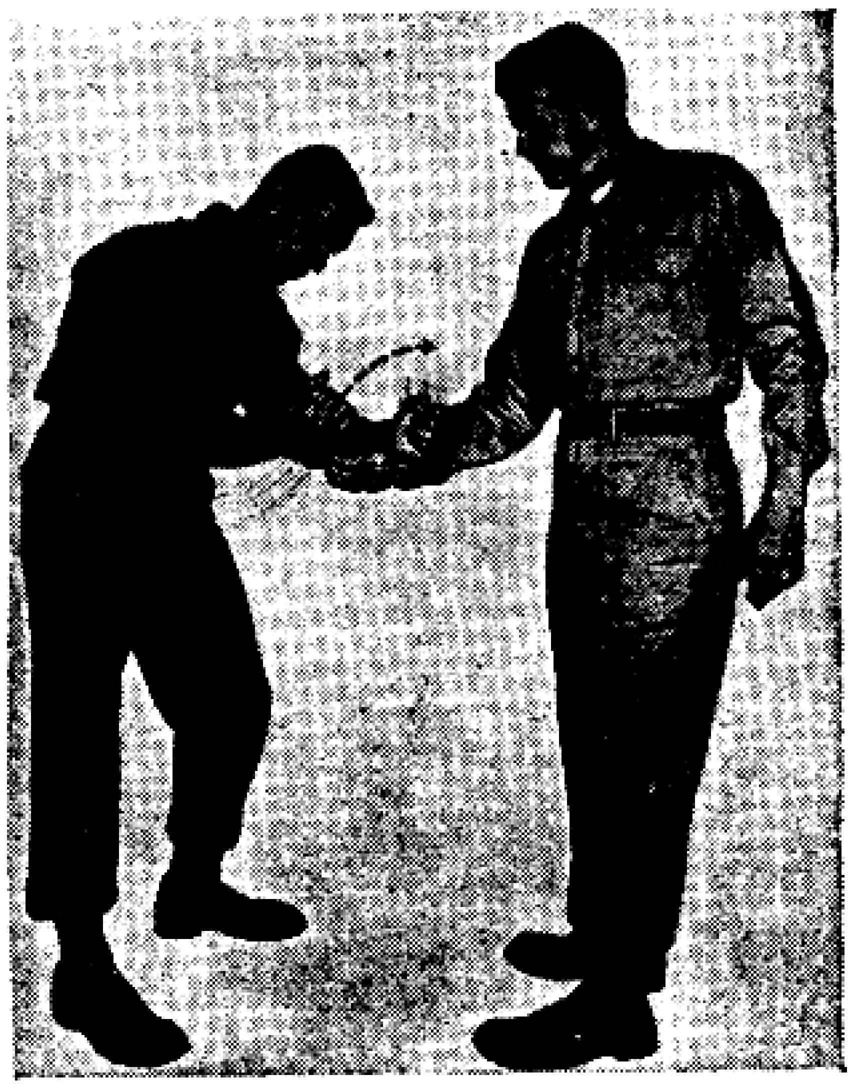

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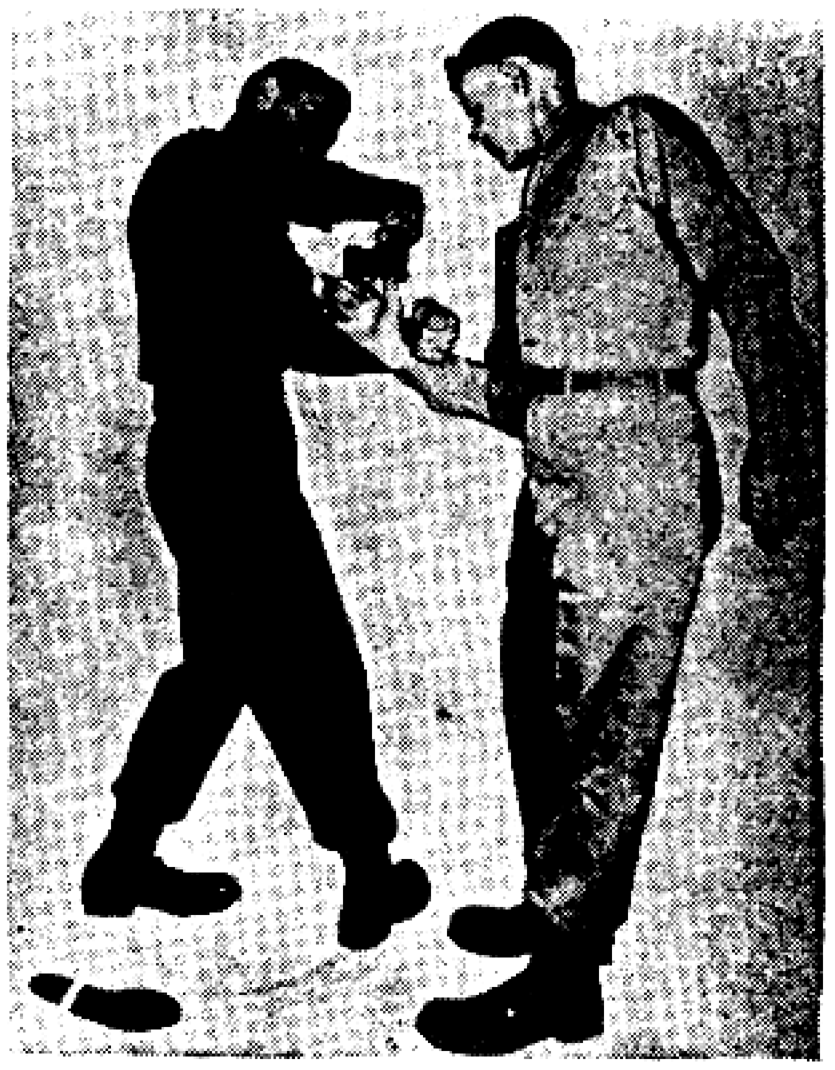

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Figure 93. Counter against pistol in front—Continued

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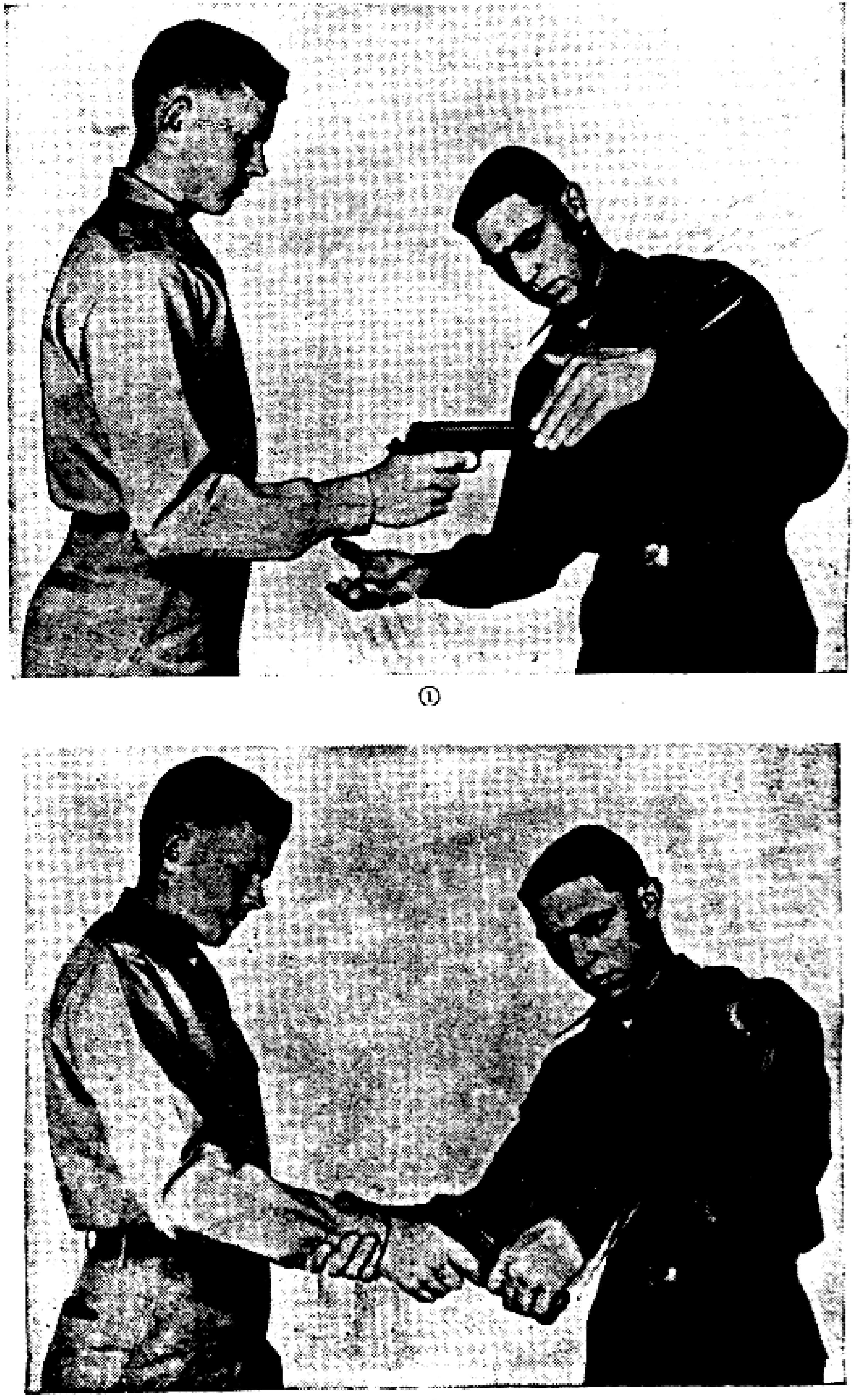

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Figure 94. Second counter against pistol in front.

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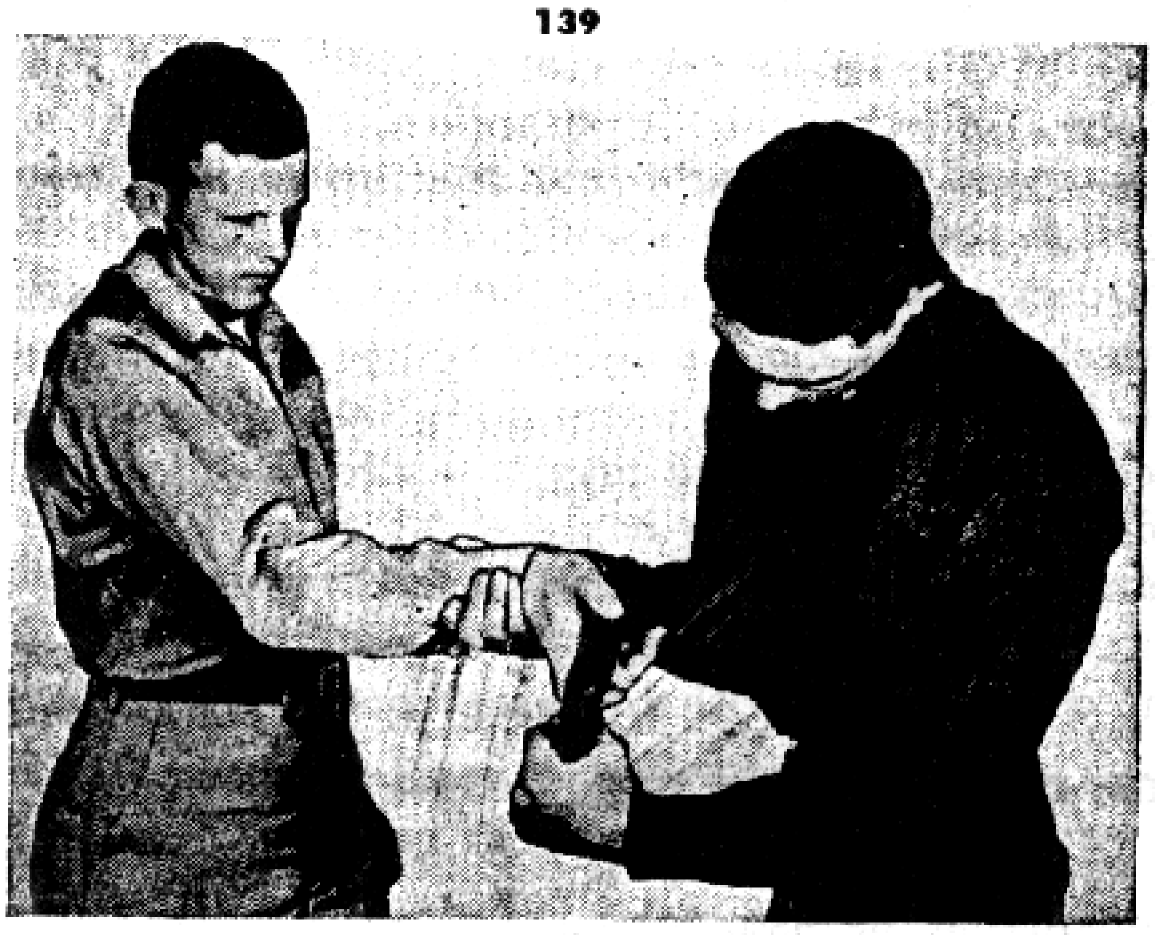

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Figure 94. Second counter against pistol in front—Continued

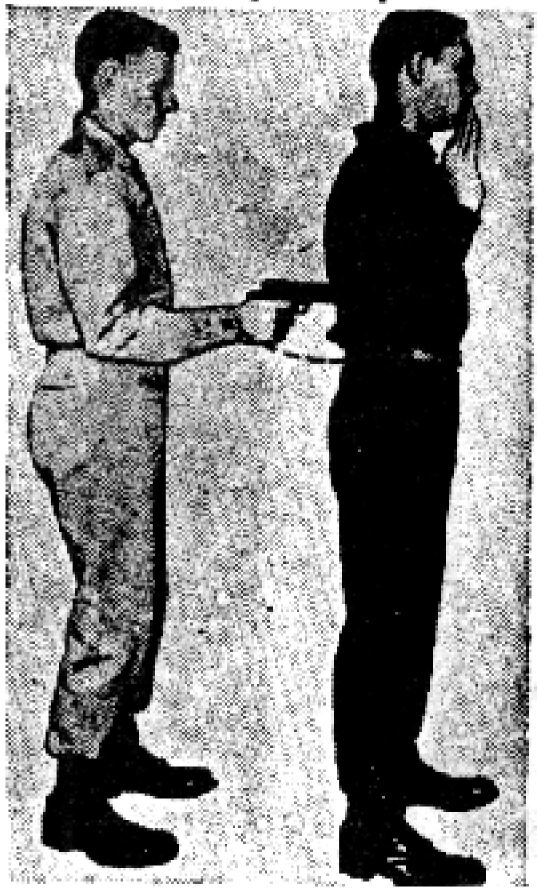

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Figure 95. Counter against pistol in back.

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(fig. 95 ②). Keep your feet in place. Bring your right arm under your opponent's right forearm and place it on his elbow joint so that his forearm rests in the crook of your right elbow (fig. 95 ③).

b. Grasp your right hand with your left hand and bend swiftly from the waist (fig. 95 ④). By doing this, you force your opponent to the ground and cause him to drop his weapon.

107. Second Counter Against Pistol in Back

a. Use this counter when you are certain that your opponent is holding the pistol in his right hand. Keep your elbows as close to your waist as possible. Twist to the left, striking your opponent's wrist or forearm with your left elbow (fig. 96 ①). Bring your left arm behind your opponent's right elbow so that his forearm or wrist rests on your shoulder or neck (fig. 96 ②).

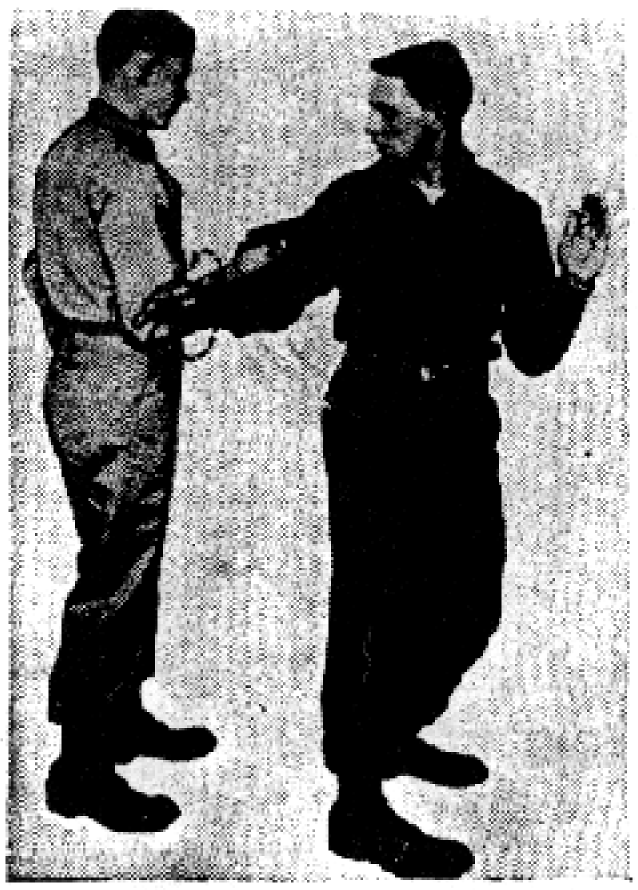

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Figure 95. Counter against pistol in back—Continued

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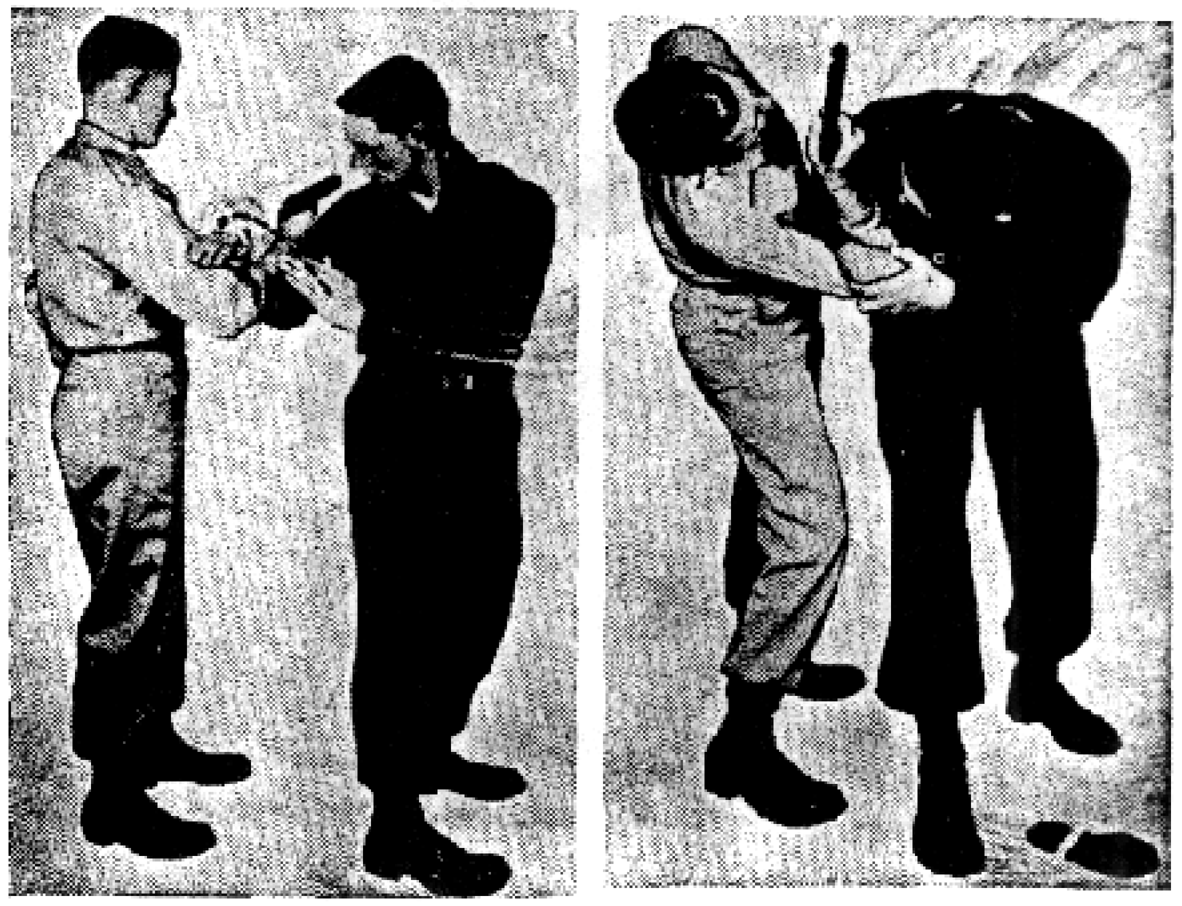

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Figure 95. Counter against pistol in back—Continued

b. Grasp your left hand with your right hand and press your left forearm against your opponent's right elbow (fig. 96 ③). A swift twist to the front brings your opponent to the ground. With added pressure, you can break his arm. During the entire operation, the muzzle of the pistol is always pointed elsewhere.

108. Third Counter Against Pistol in Back

In this counter, it does not matter whether your opponent holds the pistol in his right or left hand because your actions are the same. The description given is for the pistol held in the left hand. Figure 97 ① illustrates the holdup.

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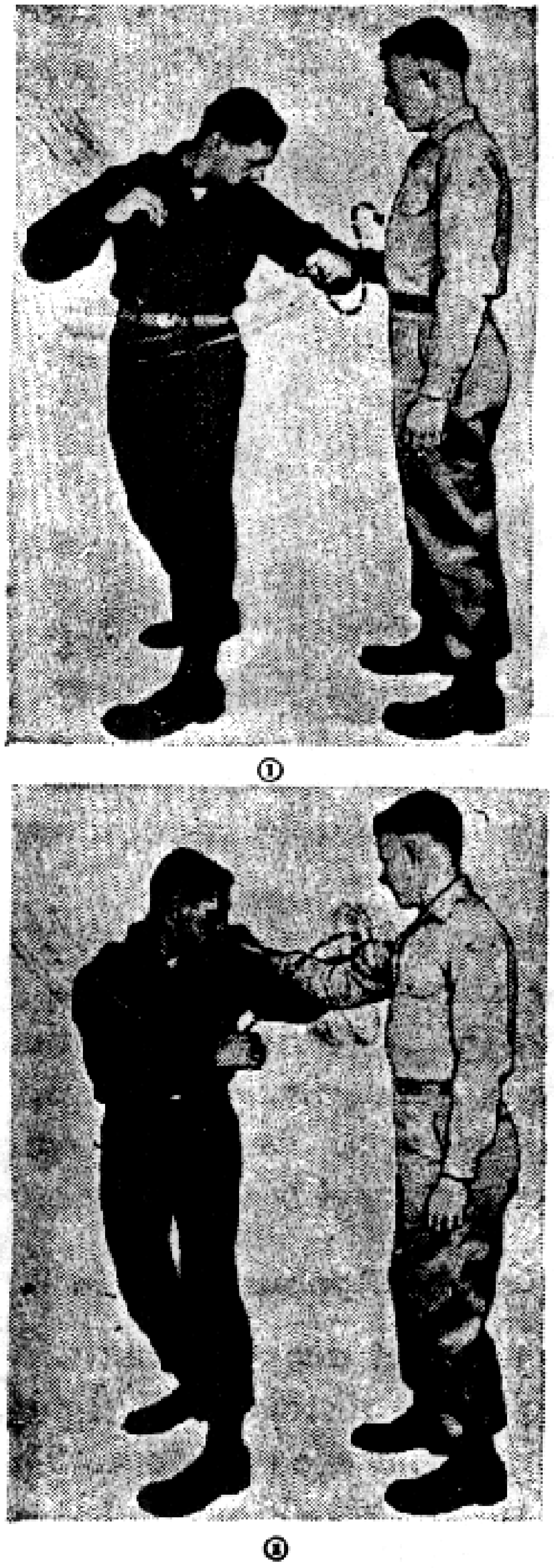

Figure 96. Second counter against pistol in back.

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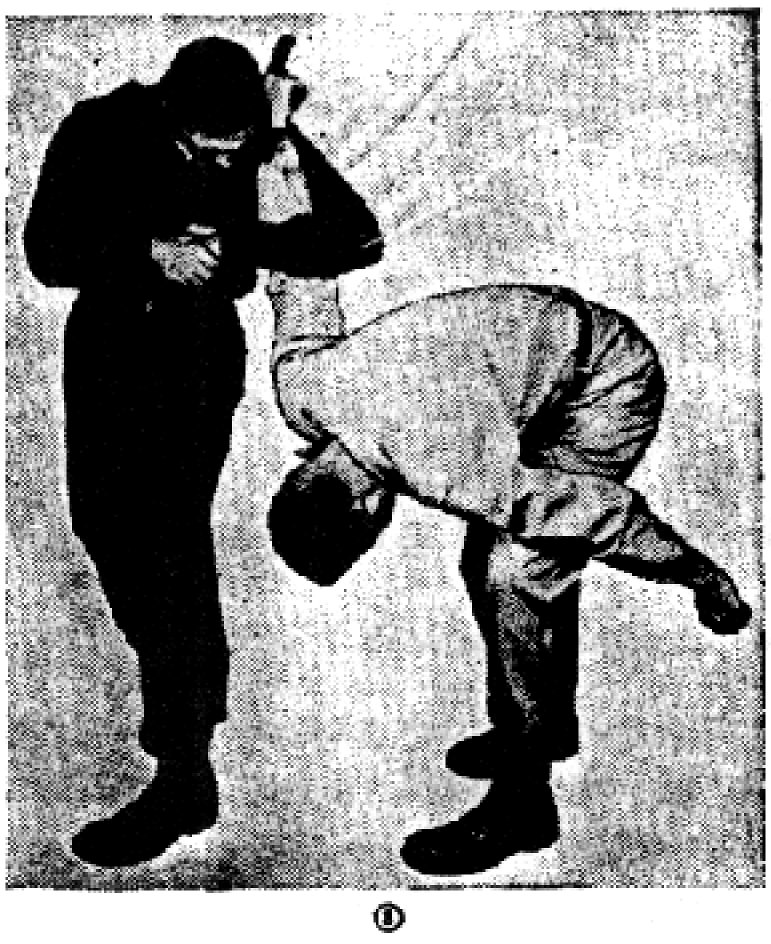

Figure 96. Second counter against pistol in back—Continued

a. Twist your body to the right striking your right elbow against your opponent's hand or wrist (fig. 97 ②).

b. Pivot to the right and place your left wrist against your opponent's left wrist, grasping the pistol barrel with your right hand, palm up. Apply pressure to his hand and trigger finger by pushing the barrel toward his upper arm. This releases his hold on the pistol and may break his index finger (fig. 97 ③). You now have the pistol in your right hand, opposite your left shoulder. By twisting forcefully to the right, you can strike your opponent on the chin or neck with the pistol butt (fig. 97 ④).

109. Counter Against Pistol in Back of Neck

a. This counter is practical only when you are certain that the pistol is held in your opponent's right

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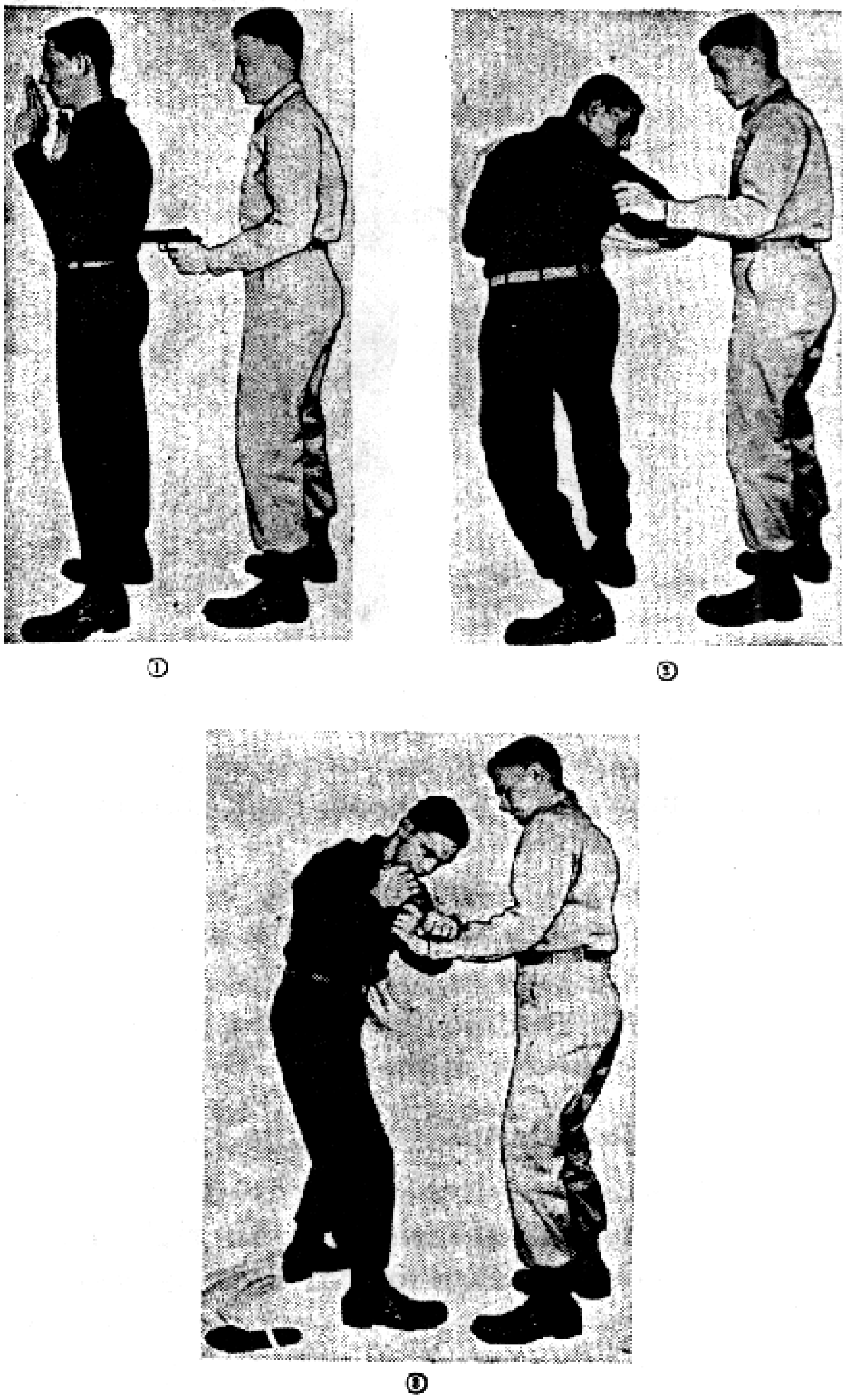

Figure 97. Third counter against pistol in back.

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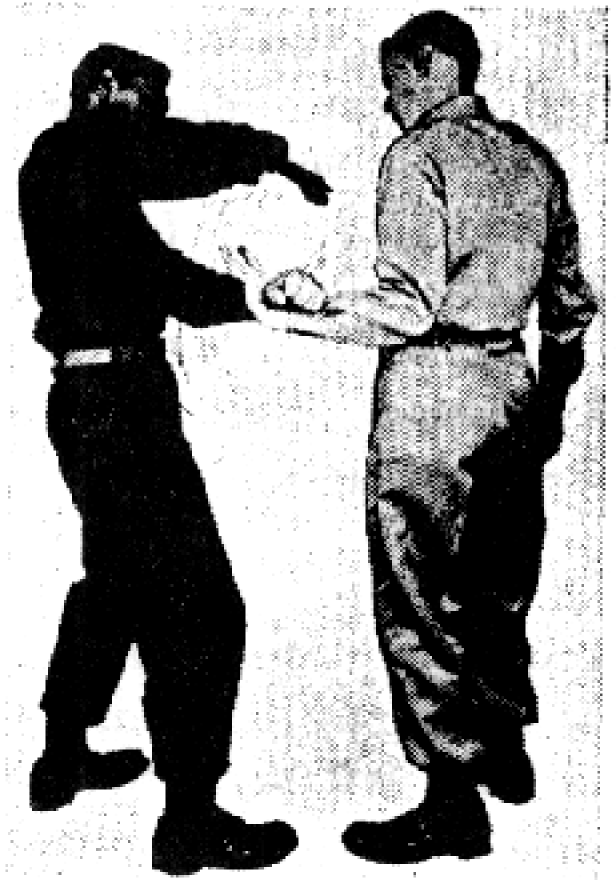

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Figure 97. Third counter against pistol in back—Continued

hand. In raising your arms, bring your elbows shoulder high (fig. 98 ①). Twist your body to the left and bring your left arm under your attacker's right elbow (fig. 98 ②).

b. Reach across with your right hand and grasp your own left hand. Twist forward and put pressure on your opponent's elbow with your left forearm. You can either break his arm or force him to the ground, causing him to release his weapon (fig. 98 ③).

110. Second Counter Against Pistol in Back of Neck

Use this counter primarily for an attack with the pistol held in the right hand. The initial move, however, can be used for a right- or left-handed attack.

a. Hold the elbows shoulder high (fig. 99 ①). Twist your body to the right and, at the same time, bring your right upper arm over your opponent's right wrist (if the pistol should be in your opponent's left hand, bring it over his left wrist) (fig. 99 ②).

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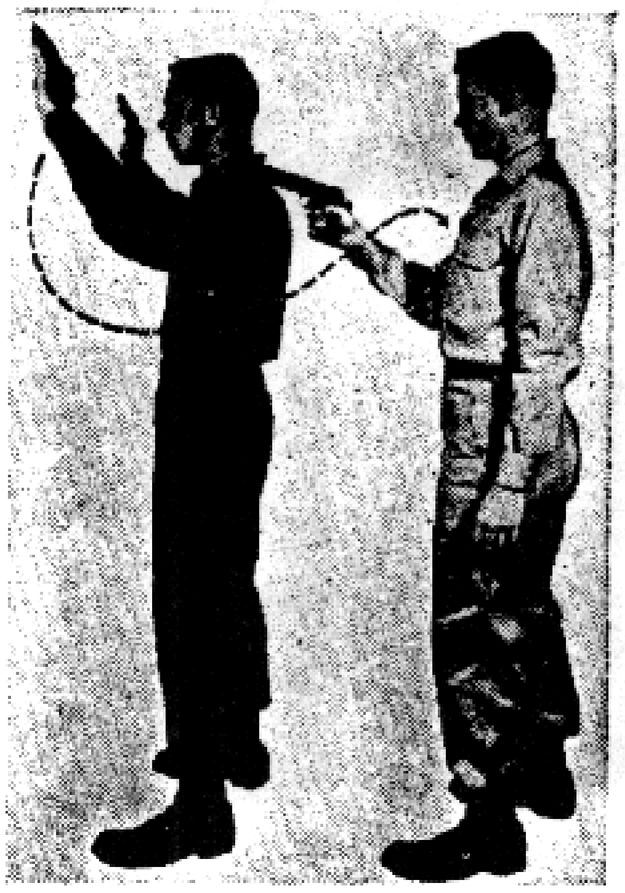

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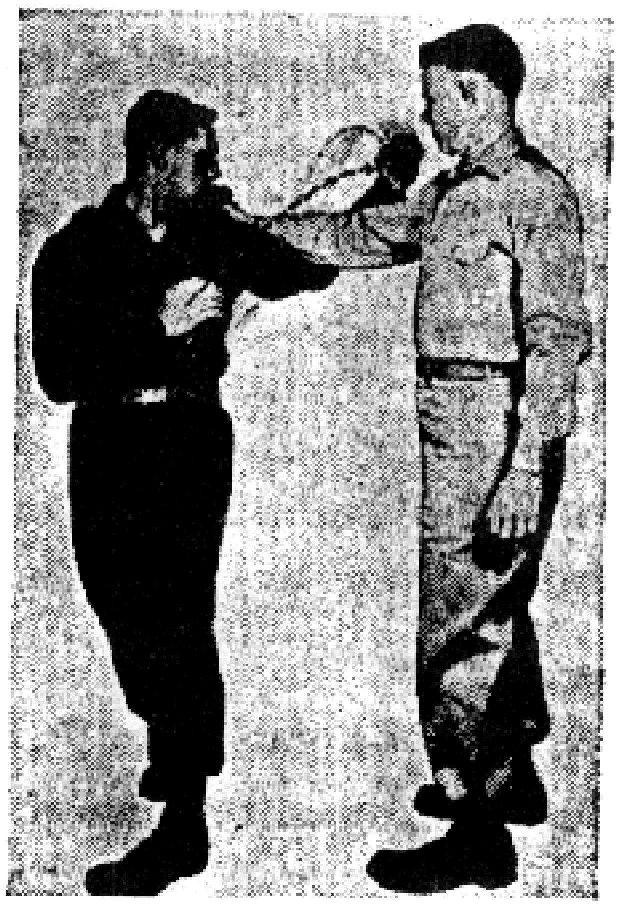

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Figure 98. Counter against pistol in back of neck.

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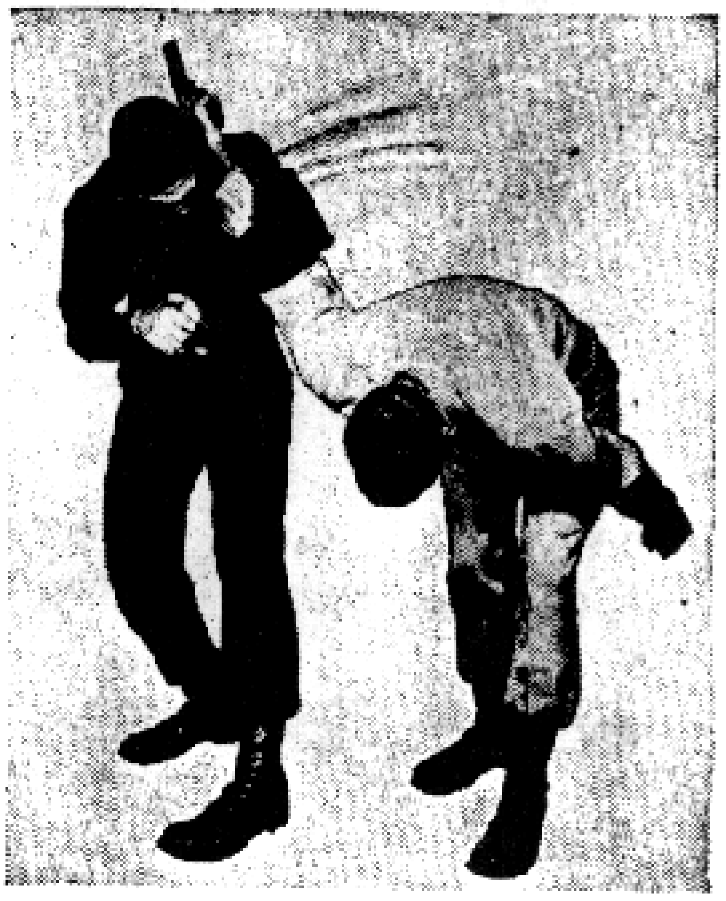

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Figure 98. Counter against pistol in back of neck—Continued

b. Pivot on your right foot and place your left foot close to your opponent's right foot. Hold your opponent's wrist close to your right side with your right upper arm. Cross your left arm under his right upper arm and grasp the left lapel of his shirt or jacket with your left hand (fig. 99 ③). Hold his right wrist close to your side and lift with your left upper arm, applying pressure to his elbow.

111. Third Counter Against Pistol in Back of Neck

Hold the elbows shoulder high (fig. 100 ①). The initial movement in this action is identical with that

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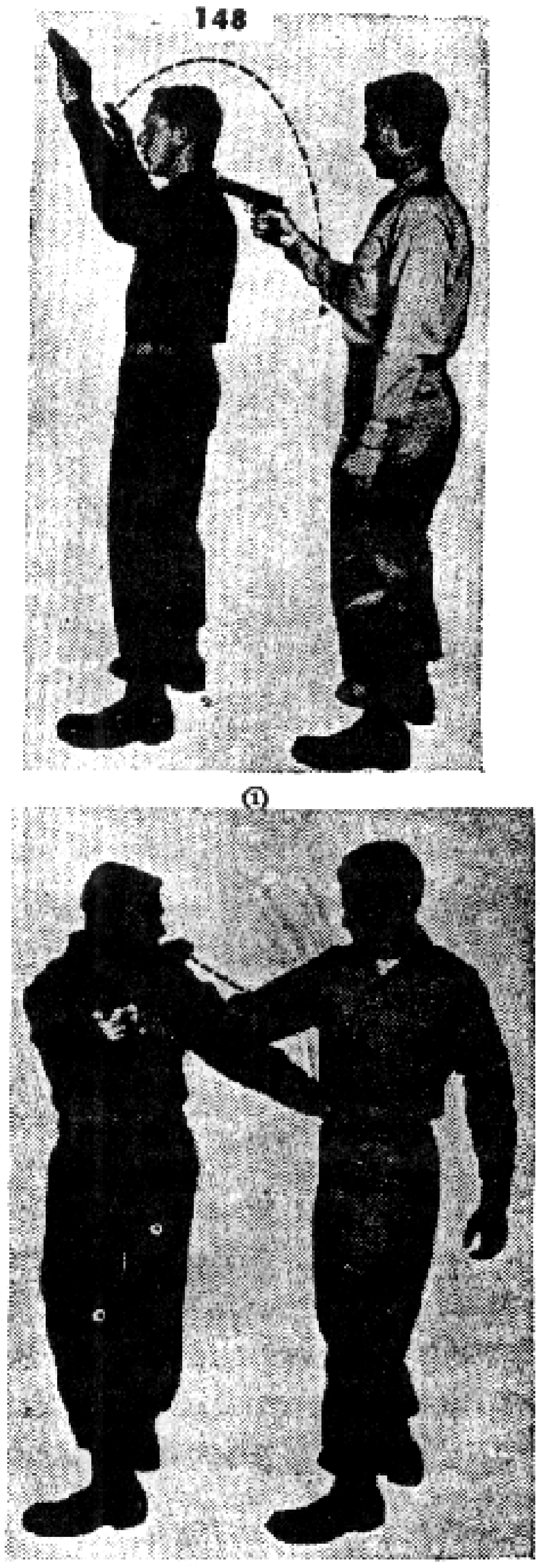

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Figure 99. Second counter against pistol in back of neck.

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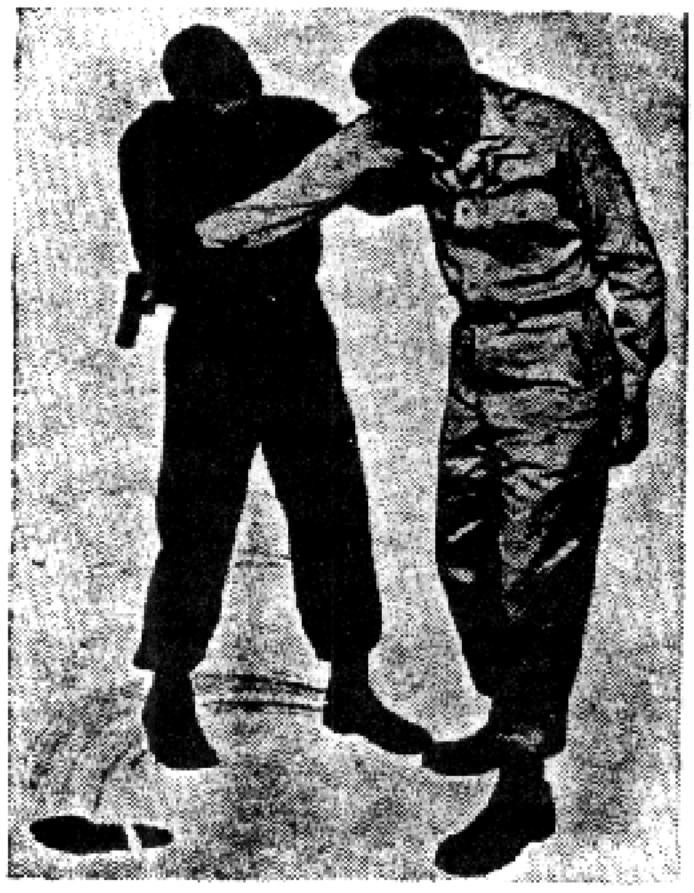

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Figure 99. Second counter against pistol in back of neck—Continued

shown in figure 99 ②. Twist your body to the right and strike your opponent's left wrist with your right arm (fig. 100 ②). Pivot on your right foot and place your left hand against your opponent's shoulder or upper arm. Bring your right forearm or wrist under your opponent's left elbow and lock it to your left forearm (fig. 100 ③). Apply pressure and cause your attacker to drop his weapon. Severe pressure can break his arm.

112. Helping a Friend

As you approach an unsuspecting opponent from his rear who is holding up a friend, carry your right hand low and your left hand shoulder high (fig. 101 ①). You must grasp your opponent with both

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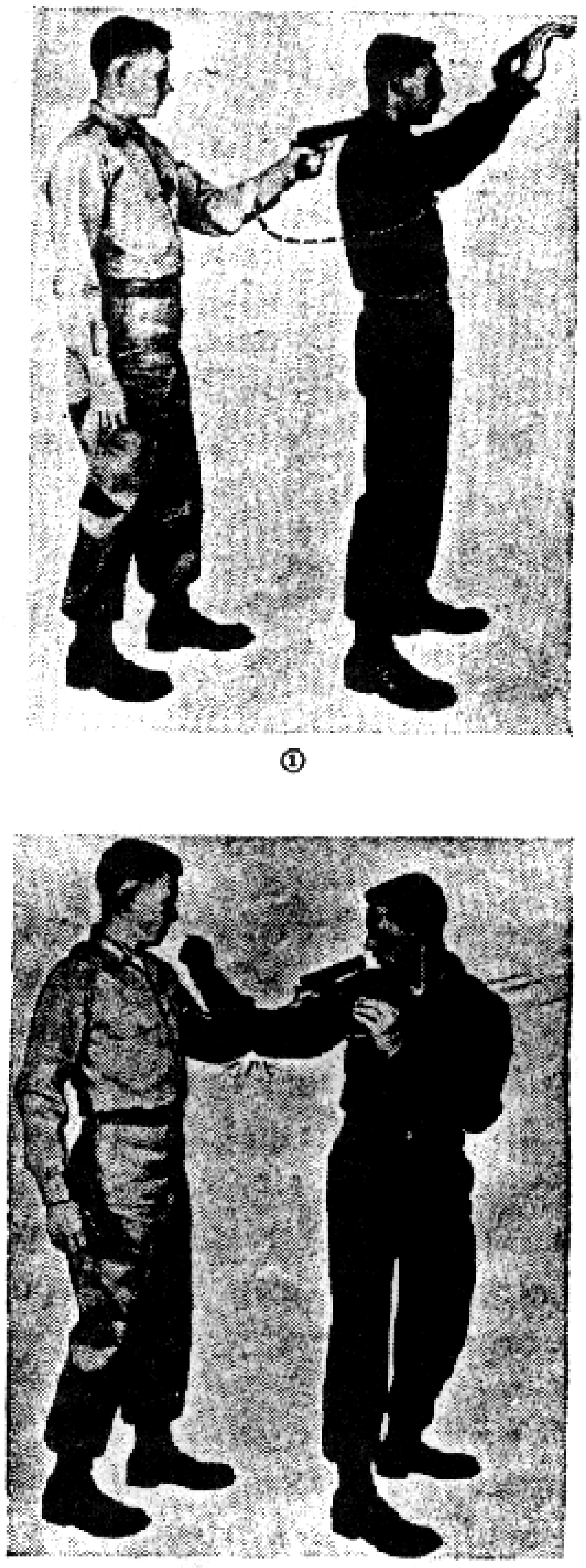

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Figure 100. Third counter against pistol in back of neck.

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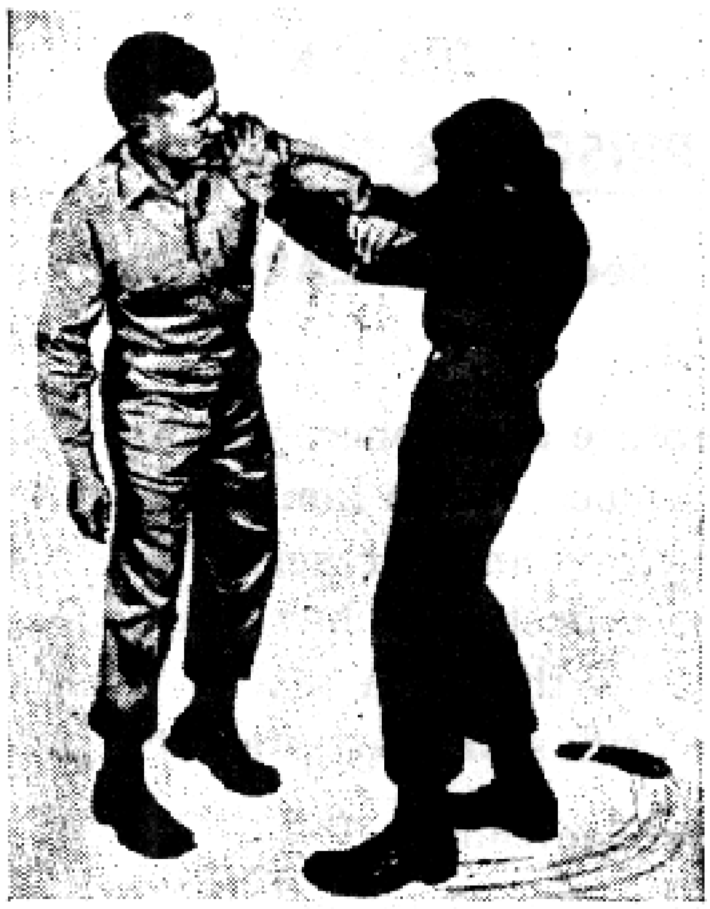

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Figure 100. Third counter against pistol in back of neck—Continued

hands at the same time. Your right hand, palm up, grasps the hand holding the pistol and lifts it, while your left hand pushes his right upper arm from behind (fig. 101 ②). Turn your body to the left and continue to apply pressure by pushing with your left hand and pulling his right hand backward (fig. 101 ③). This causes him to drop to the ground or suffer a dislocated shoulder.

113. Actions Against Opponent Who Is Holding You and Your Friend at Gun Point

The original position in this holdup is shown in figure 102 ①. The gunman is moving the muzzle of the pistol from your friend to you and back again. You are standing on your friend's left.

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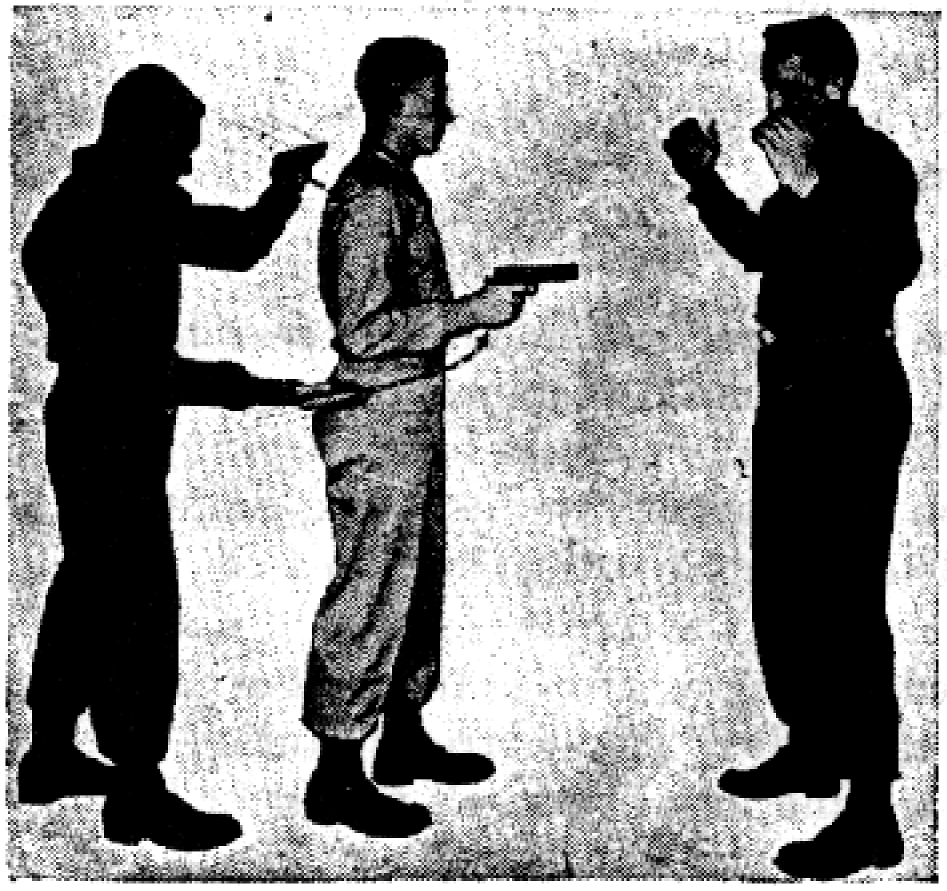

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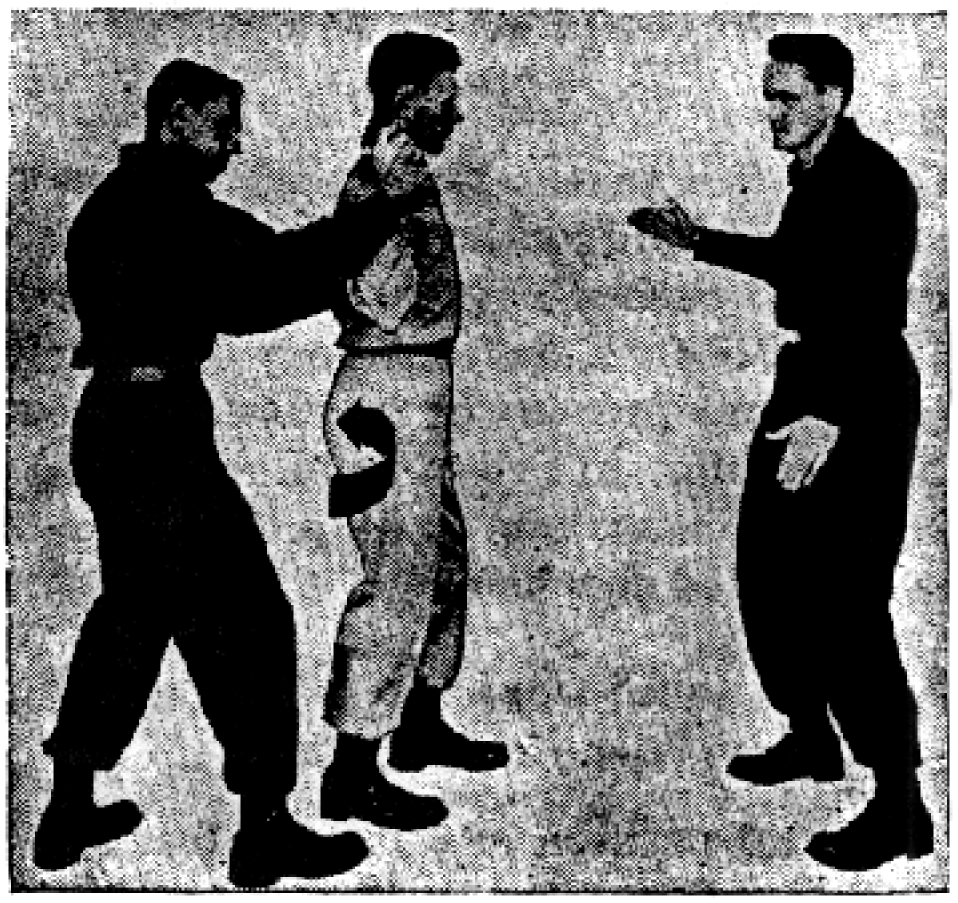

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Figure 101. Attacking an unsuspecting gunman from his rear.

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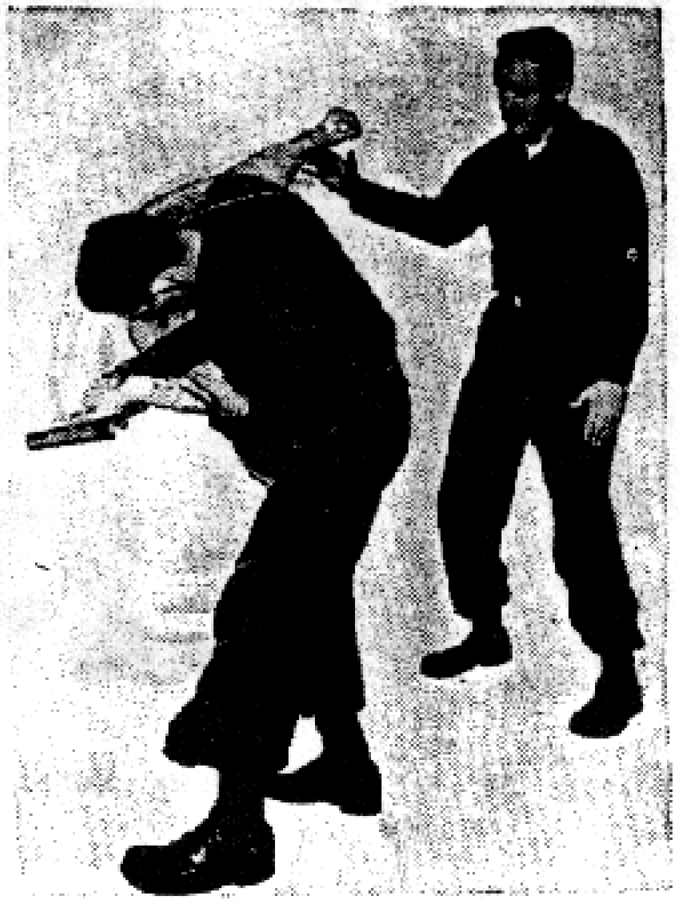

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Figure 101. Attacking an unsuspecting gunman from his rear—Continued

a. As the weapon swings away from you, step forward with your left foot, place your left hand on the back of the attacker's gun hand, and push forcefully to his left (fig. 102 ②).

b. Take a step with your right foot and a quick long step with your left foot. Your movement brings you in front of your opponent, with your back to him. At the same time, twist his hand to his left, turning it so his palm is turned up and his right elbow comes in contact with your left armpit (fig. 102 ③). Bear down on his right elbow with your armpit and lift up on his hand, causing him to release his weapon or suffer a broken arm.

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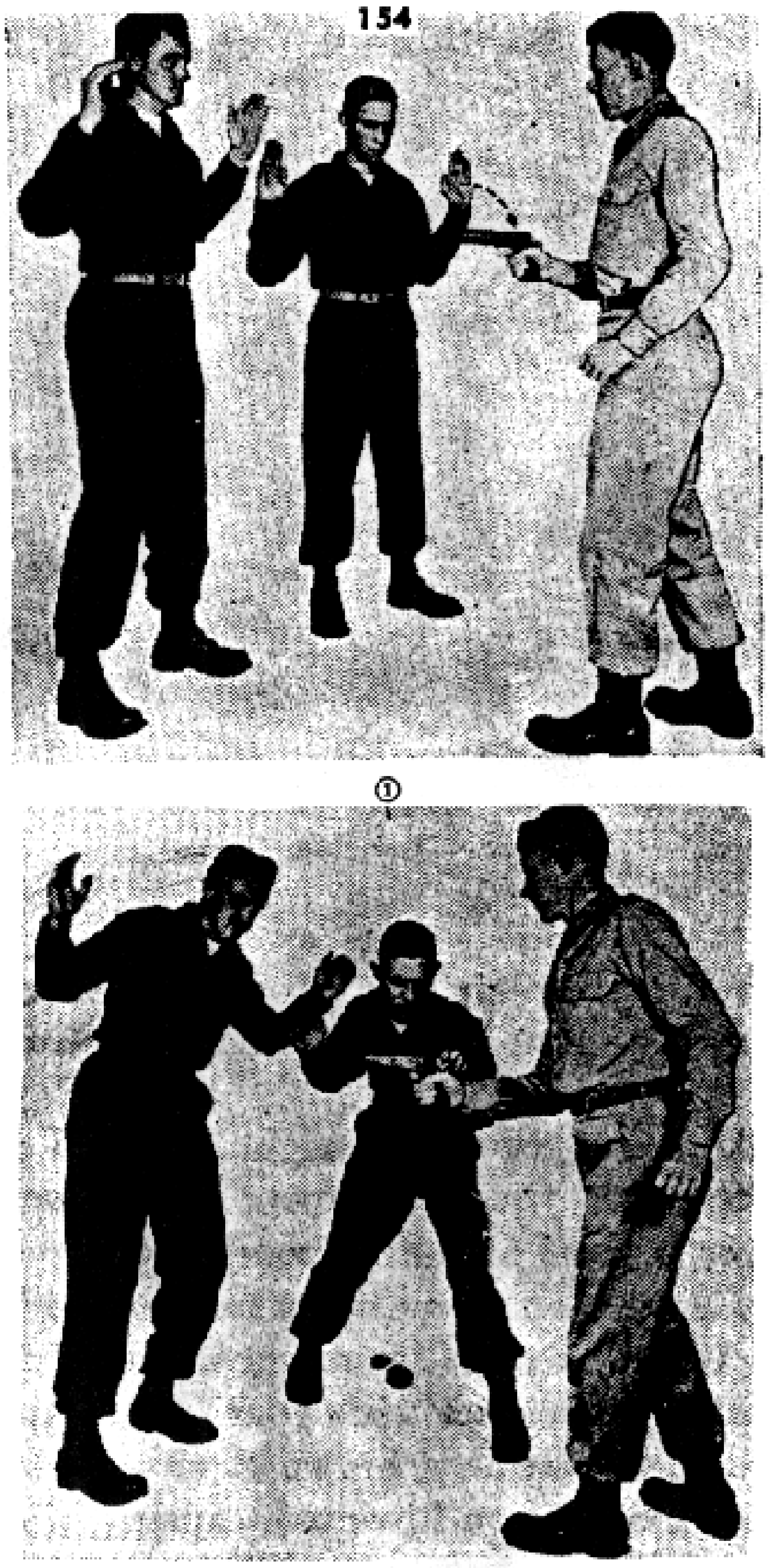

Figure 102. Actions when you and your friend are held up.

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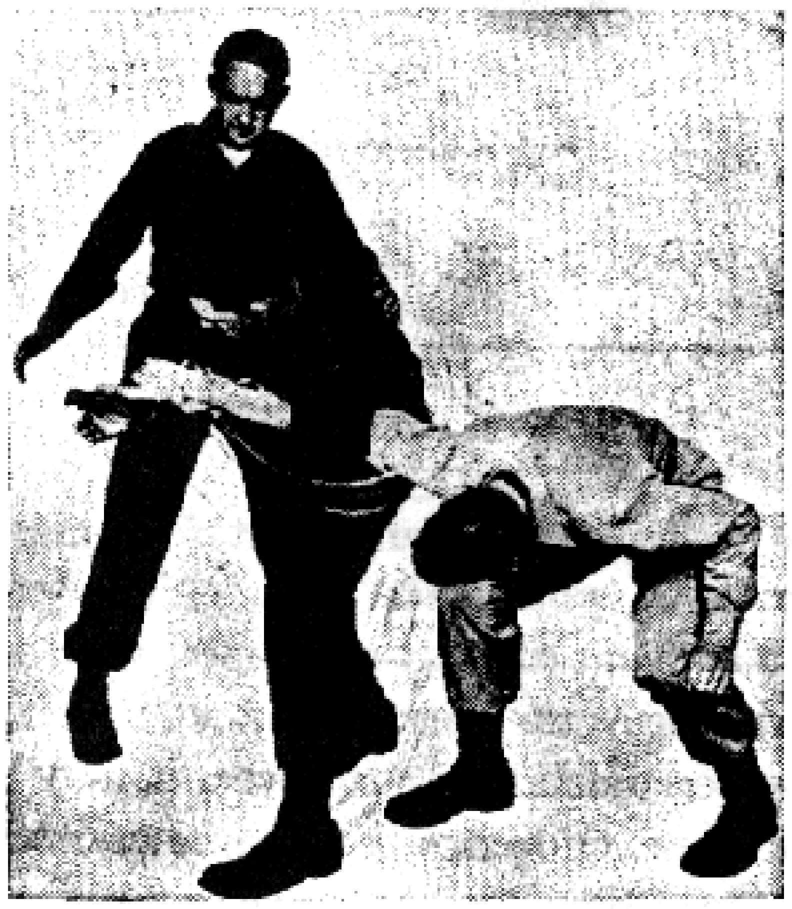

Figure 102. Actions when you and your friend are held up—Continued

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CHAPTER 9

PRISONER HANDLING

Section I. SEARCHING

114. General

If you capture a prisoner, you will not normally search him alone. Move him to the rear where he can be covered by another person while you search. In extreme circumstances, however, it may be necessary to make a thorough search unassisted. Two methods for a rifle search are presented in this section.

115. Rules for Searching

The rules you should follow when searching a prisoner are—

a. Indicate by inference, speech, and actions that you are completely confident and will fire if necessary.

b. Do not let your prisoner talk, look back, move his arms, or otherwise distract you.

c. Never attempt to search a prisoner until you have him in a position of extremely poor balance.

d. Don't move within arm's reach of your prisoner until you have him in a position of extremely poor balance.

e. If armed with a pistol, hold it at your hip in a ready position, and keep it on the side away from your prisoner. Change the pistol to your other hand when searching his other side.

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f. When you have assistance, keep out of your partner's line of fire. One soldier conducts the search while the other remains far enough away to observe the prisoner at all times.

g. Don't relax your guard after you have completed your search.

116. Technique of Search

a. The "pat" or "feel" method of searching a prisoner will reveal most weapons and concealed objects. Search the prisoner's entire body, paying particular attention to his arms, armpits, back, groin area, and legs. Thoroughly pat the clothing folds around his waist, chest, and the top of his boots. Knives can be concealed on a string around the neck or taped to any area of the body. Take extreme caution when putting your hand in a prisoner's pocket or in the fold of a garment so he won't be able to clamp your arm and trip you over his leg.

b. After the initial search, a detailed search is made when the prisoner is moved to the rear. Force him to disrobe completely and examine his entire body from the soles of his feet to the top of his head.

117. Prone Method of Searching When Armed With a Rifle

Make the prisoner lie down on his stomach so that his arms are completely over his head and close together. His legs are also completely extended, feet close together. Place the muzzle of the rifle in the small of his back, keeping the gun upright. Grasp the rifle tightly around the small of the stock, index finger on the trigger (fig. 103). After searching his back, order him to turn over and repeat the process. Twist the muzzle into the prisoner's clothing to prevent it from slipping. You can also use this method when armed with a pistol. Keep the pistol at your hip while searching. You will have to use arm-and-hand signals for non-English speaking prisoners.

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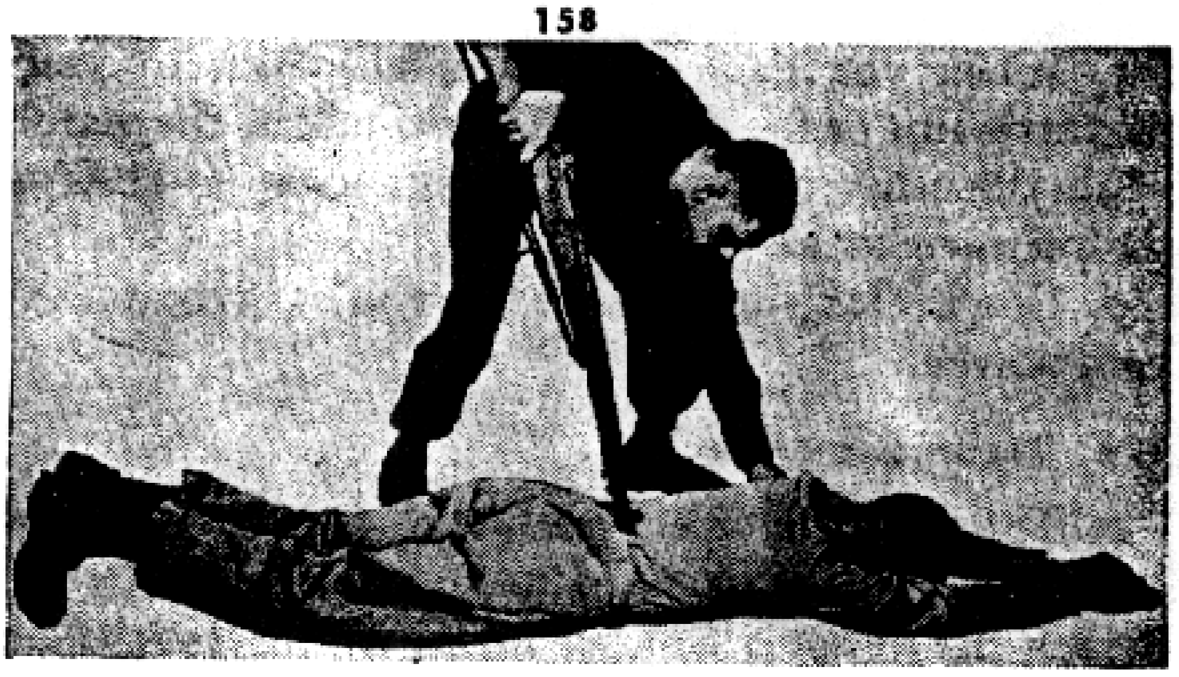

Figure 103. The prone method of searching makes it difficult for a prisoner to disarm his searcher.

118. Kneeling Method of Searching When Armed With a Rifle

The prisoner interlocks his hands behind his head and kneels. He bends forward as far as possible until he is just able to maintain his balance. While searching his left side, hold the rifle in your right hand, muzzle jammed into the small of his back. Put your left leg between his legs and against his buttocks (fig. 104). In this position, you can quickly knock him flat by thrusting with the left knee. When searching his right side, hold the rifle in your left hand and put your right leg between his legs, knee against his buttocks. You can also use this method when armed with a pistol. Keep the pistol at your hip while searching.

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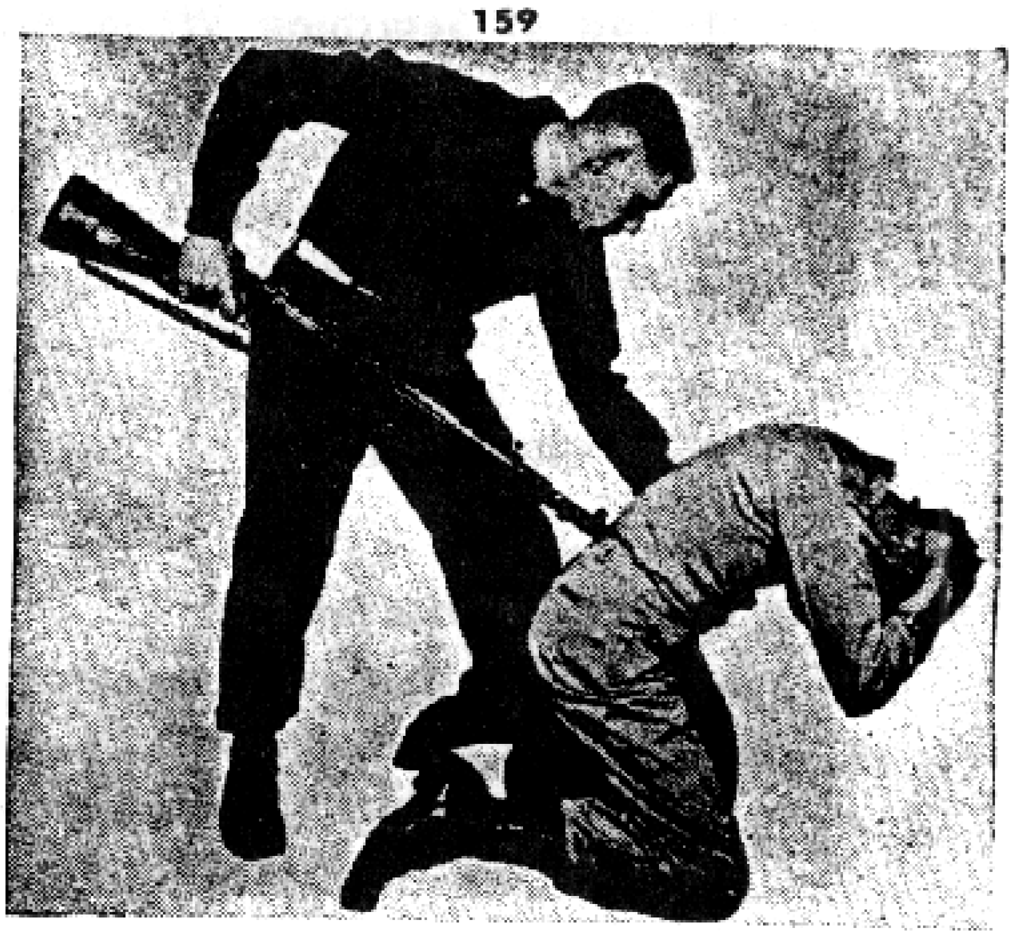

Figure 104. The searcher keeps his left leg pressed into the prisoner's buttocks to knock the prisoner off balance, if the situation arises.

119. Wall Method of Searching When Armed With the Pistol (For Another Method of Wall Searching See FM 19–5)

Have the prisoner lean against a wall or a tree, one hand over the other and feet together and crossed as far to the rear as possible. This gives him extremely poor balance. To search his left side, place your left foot in front of his feet, keeping the pistol at your right hip (fig. 105). If the prisoner attempts to move, kick his feet out from under him. To search his right side, move to that side, switching the pistol to your left hand and placing your right foot in front of his feet.

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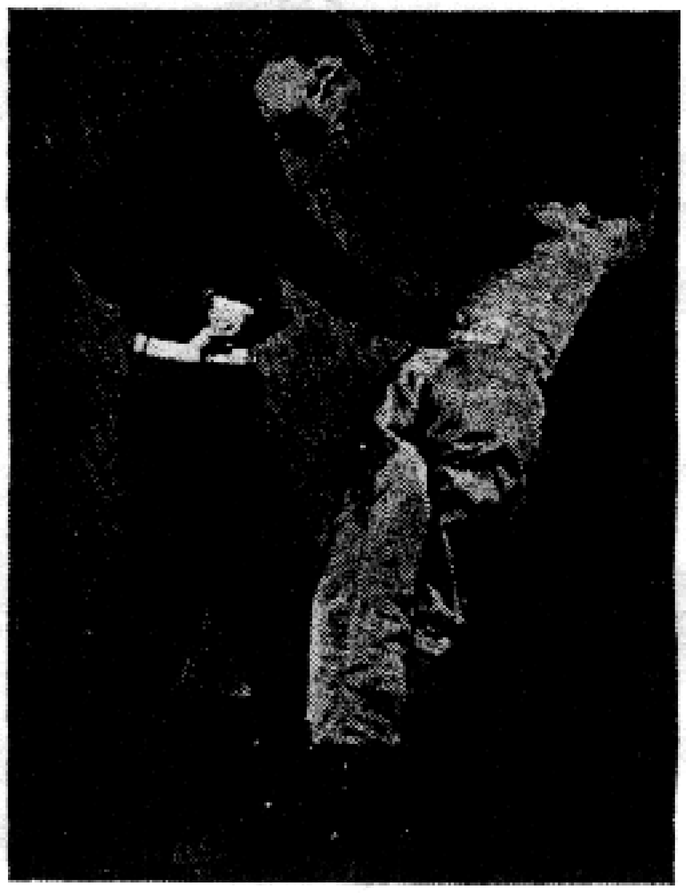

Figure 105. The prisoner is kept off balance by leaning well forward with his legs and arms crossed.

120. Standing Method of Searching When Armed With a Pistol

Make the prisoner spread his legs far apart and place his hands on top of his head, fingers interlocked. While searching, keep as far from him as possible (fig. 106 ①). When you have to move close to him to search his front, place your foot against his heel, turning your body to the side to protect your groin (fig. 106 ②).

121. Searching More Than One Prisoner

a. A man armed with a pistol can search more than one prisoner at a time, using any of the methods presented in this section. While searching several prisoners, keep your eyes on all of them and do not look at your "patting" hand.

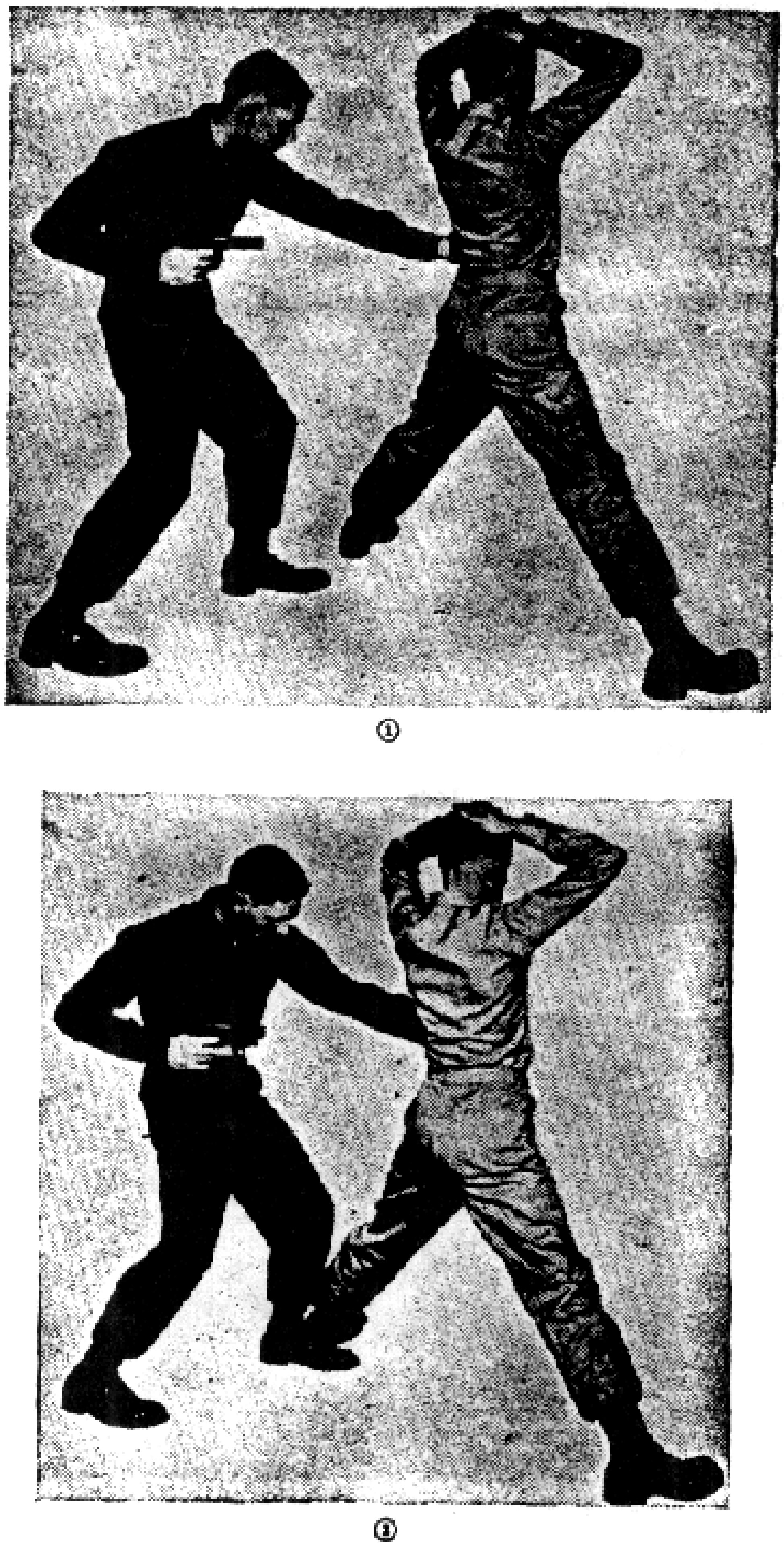

Figure 106. Search the prisoner well, but be alert at all times.

b. When using the wall method, keep the pistol in your right hand and search the left side of the first prisoner (fig. 107 ①). Step back and have him move to the far end of the line and resume the search position against the wall. Search the left side of the remaining men in the same manner. Then move to the other end of the line (fig. 107 ②). Hold the pistol in your left hand and search the right side of each prisoner, having each one move to the far end of the line as you finish.

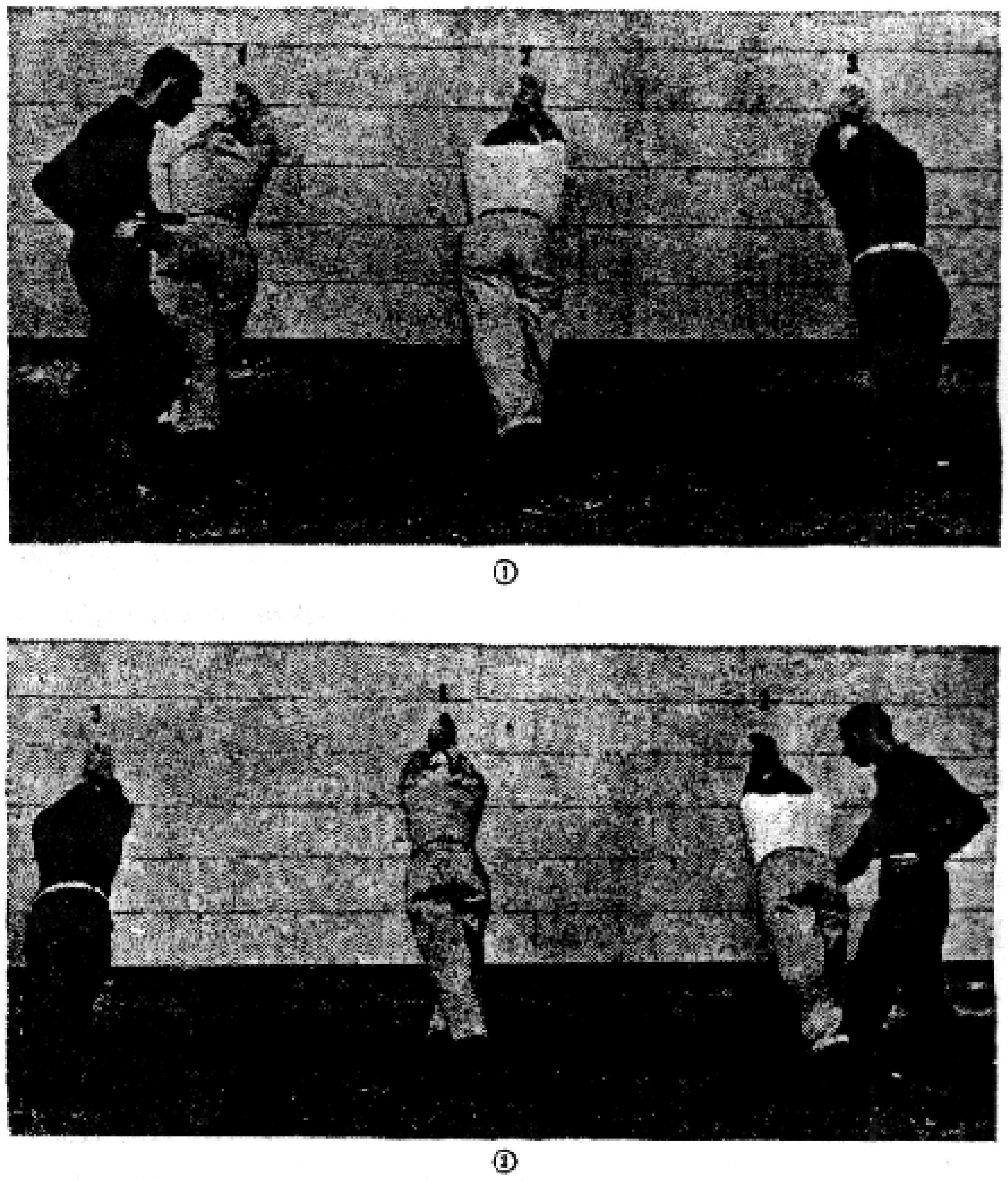

Figure 107. When searching more than one prisoner, have each searched man move to the end of the line.

c. To search more than one prisoner using the kneeling, prone, or standing methods, make them all assume the same position, in column about four or five feet apart (fig. 108). Search the rear man and then have him move to the front and resume the search position. Search the remaining prisoners from the rear, moving each to the front as you finish with him. When alone and armed with a rifle, the kneeling search is the best method to use.

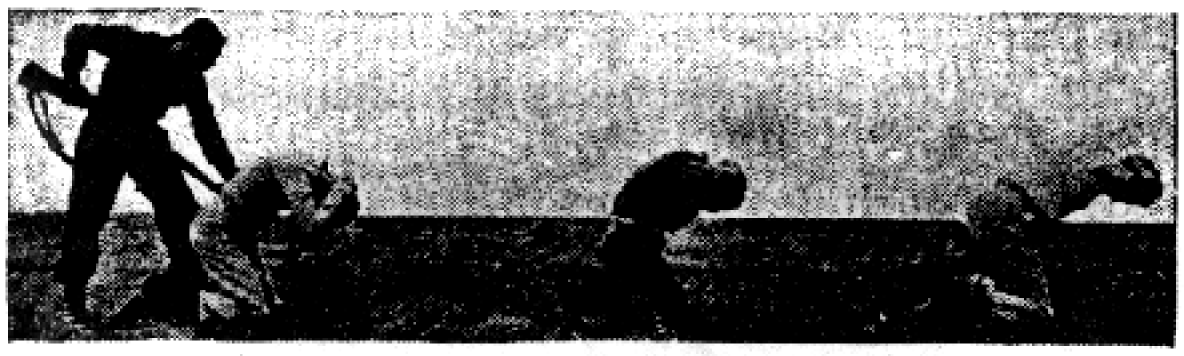

Figure 108. The kneeling search is the best method if alone and when searching more than one prisoner.

Section II. SECURING

122. General

The most effective way of controlling a prisoner is to tie him. You can use pieces of clothing or equipment to tie him securely, such as shoe laces, leather or web belts, neckties, handerchiefs, or twisted strips of cloth. If a night patrol has the mission of capturing prisoners, it should always carry a piece of rope or flexible wire.

123. Belt Tie

Take the prisoner's belt and order him to lie on his stomach. Cross his arms behind his back and place the running end of the belt toward his feet, buckle toward his back. Hold the buckle on the wrist of his bottom arm and tightly wrap the running end around his wrist several times (fig. 109 ①). Place the running end of the belt parallel with his spine and outside the wrist of the upper arm. Now wrap the running end around the wrist of the upper arm several times (fig. 109 ②). Be sure to keep the prisoner's arms as close together as possible and to wrap the belt as tight as possible. Fasten the belt in the buckle (fig. 109 ③). Although this is an effective means of tieing, you should use it only when the prisoner is under close watch.

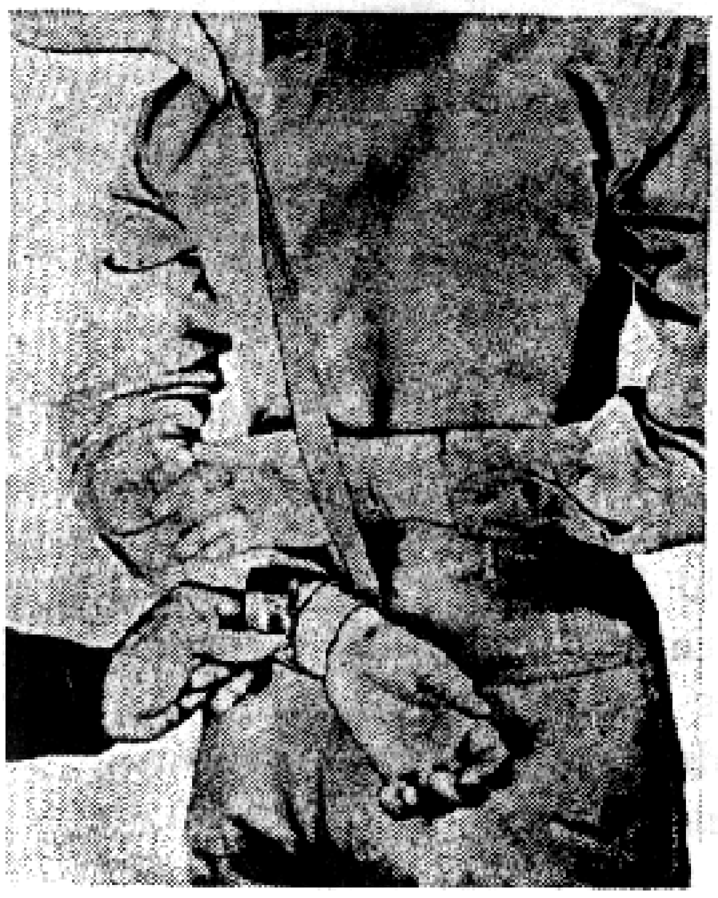

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Figure 109. The belt tie.

124. Shoe String Tie

Two 27-inch shoe strings or larger are needed for this tie. Have the prisoner remove his shoe or boot laces. You can make this tie with the prisoner's hands either in front of his body or behind his back, the latter being more effective. Place his hands back to back, wrists touching each other. Take one string and tightly wrap it completely around both wrists several times. Now wrap the end of the string around the cord between the insides of his wrist. This will further tighten the outside loops. Tie the ends of the string together with any conventional knot (fig. 110 ①). Next tie the two little fingers together, using one end of the second string. Pass the remainder of the string over the loop around the wrists and tie his thumbs together. When you pass the second string around the wrists, be sure to pull it

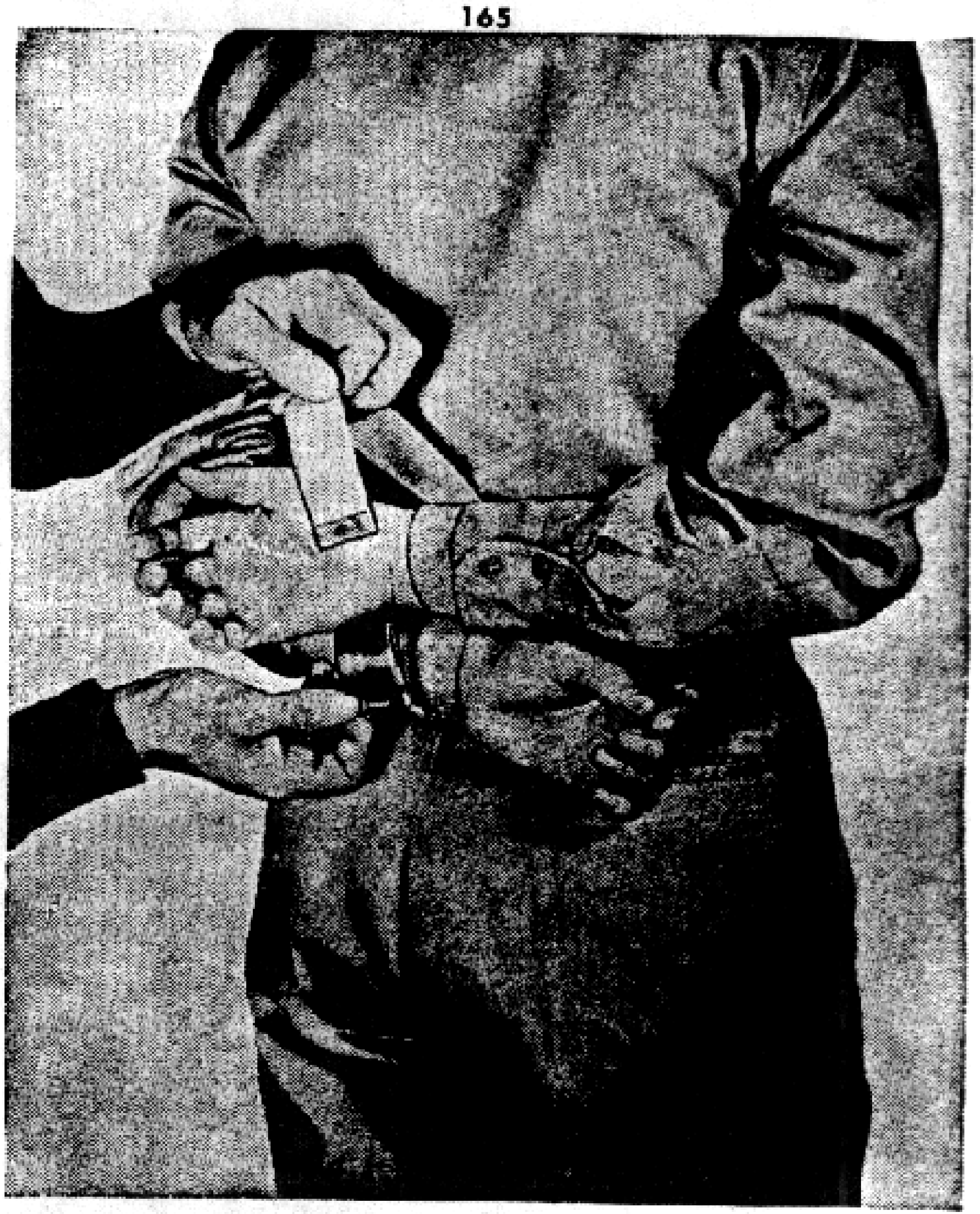

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Figure 109. The belt tie—Continued

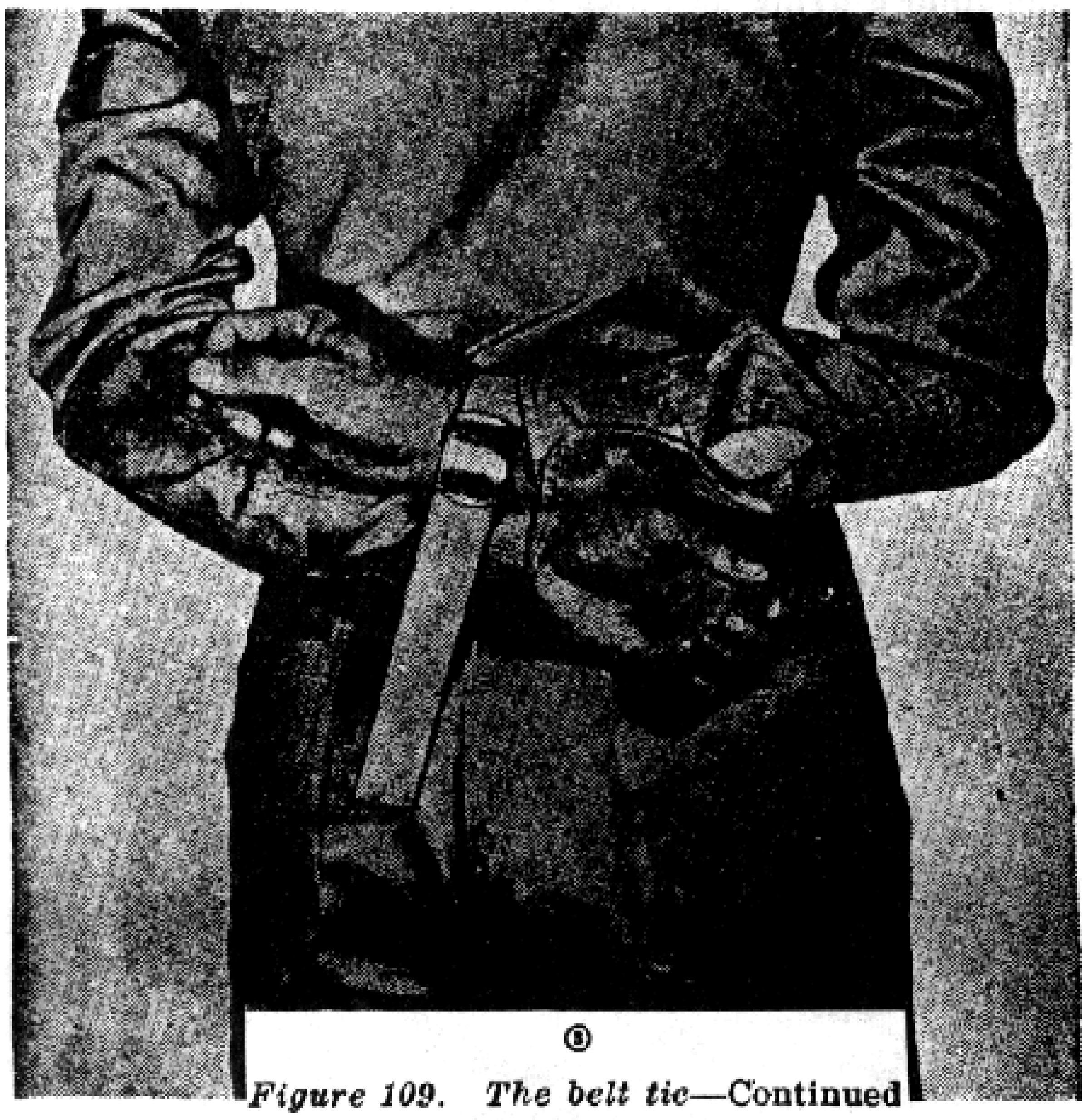

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Figure 109. The belt tie—Continued

tight and keep it tight when tieing the thumbs (fig. 110 ②).

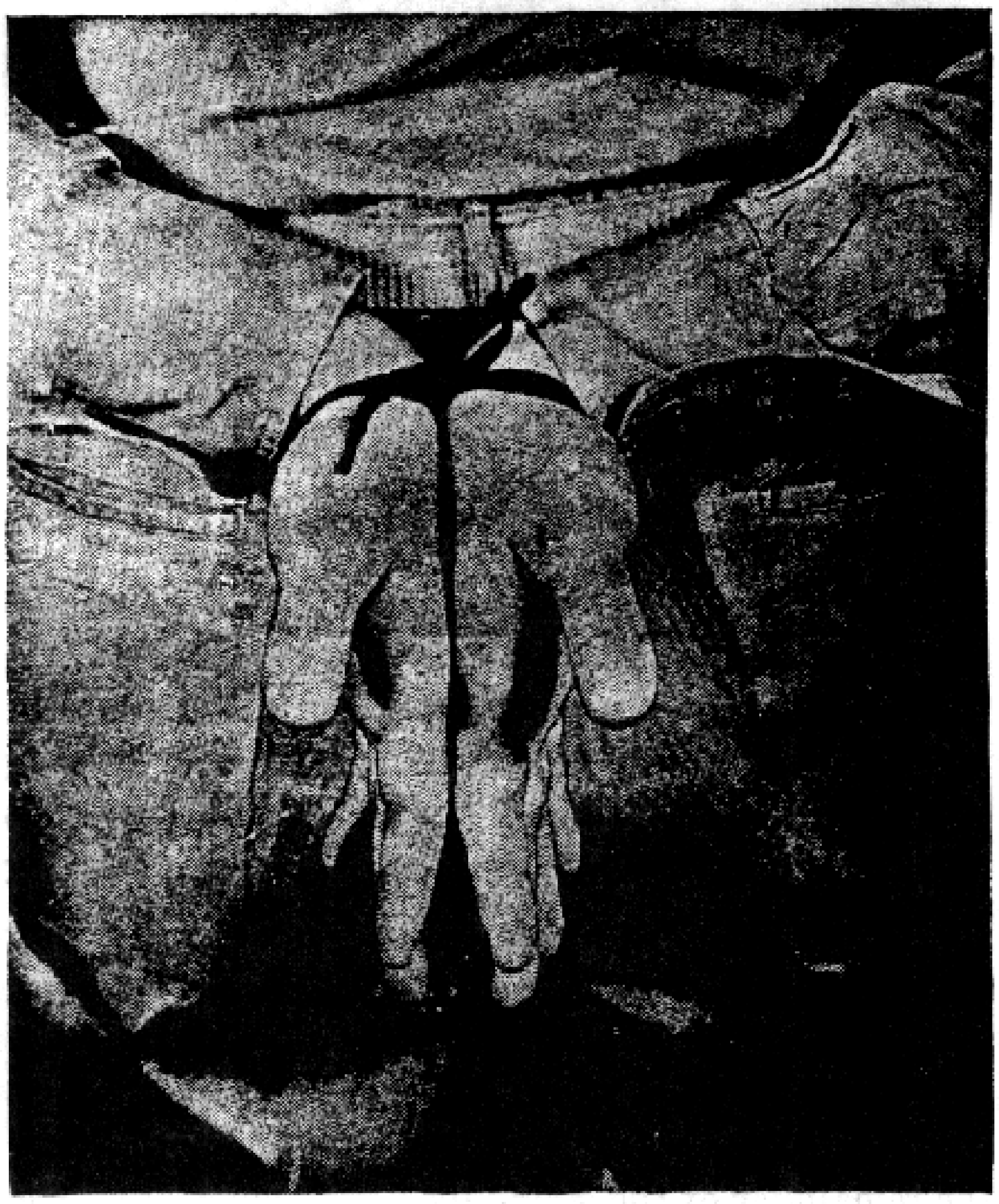

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Figure 110. Many available objects can be used to tie a prisoner's hands, such as shoe strings.

125. Lead Tie

A piece of rope or two long boot laces are needed for this tie. Make the prisoner lie down. Tie his hands behind his back, using any conventional knot.

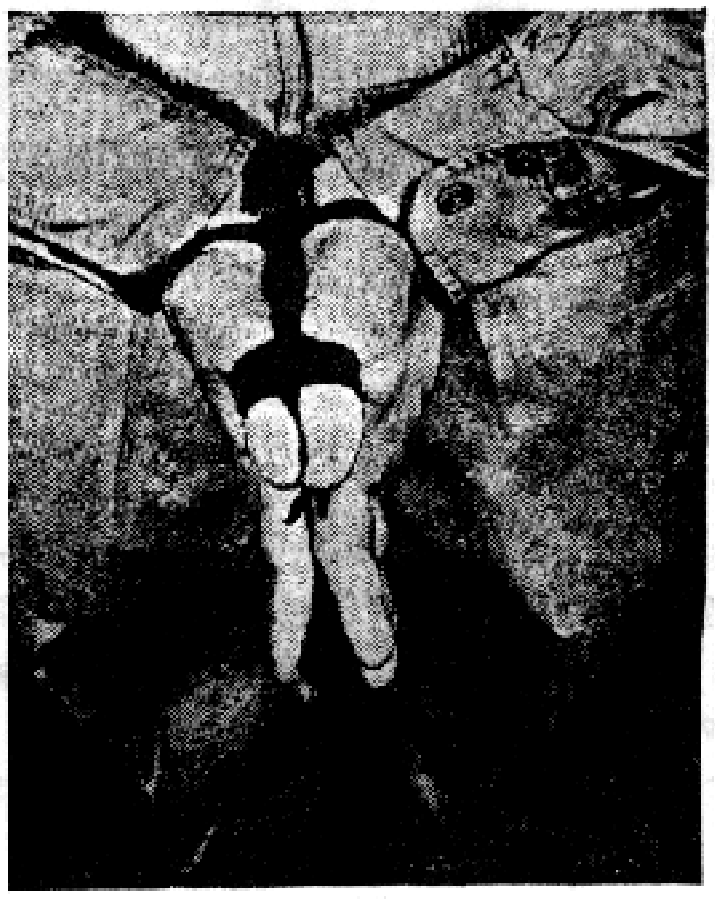

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Figure 110. Many available objects can be used to tie a prisoner's hands, such as shoe strings—Continued

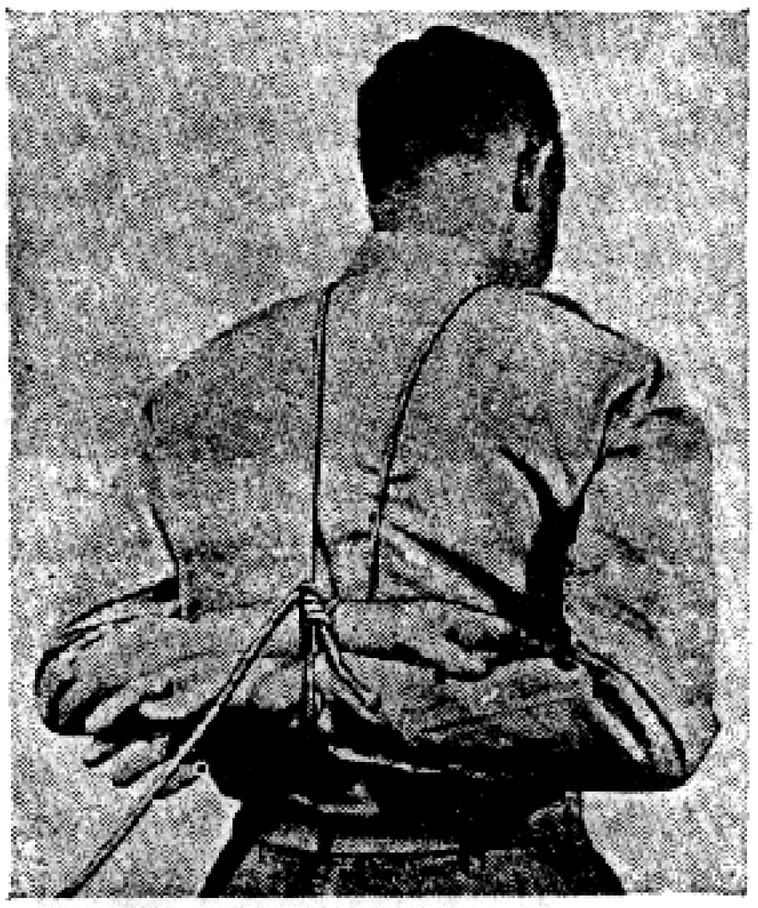

Figure 111. Lead tie.

Force his arms up behind his back in a strained position. Pass the rope around his neck and tie it around his wrists. The length of the loop around his neck should be short enough to force the man to keep his arms in a strained position to relieve pressure on his throat (fig. 111). The prisoner can be easily subdued by jerking on the rope as you walk behind him.

126. Hog Tie

Tie the prisoner in the lead tie (fig. 111). Cross his ankles and, after doubling his legs up behind him, tie them with the rope so that they remain in position. Any struggle to free himself will result in strangulation (fig. 112). When correctly applied, there is no escape from this tie.

Section III. GAGGING

127. Handkerchief

A gag prevents a prisoner from crying out. Force a handkerchief or a strip of cloth into the prisoner's mouth. A lump of turf will suffice if nothing else is available. Tie a handkerchief around the prisoner's mouth (fig. 113).

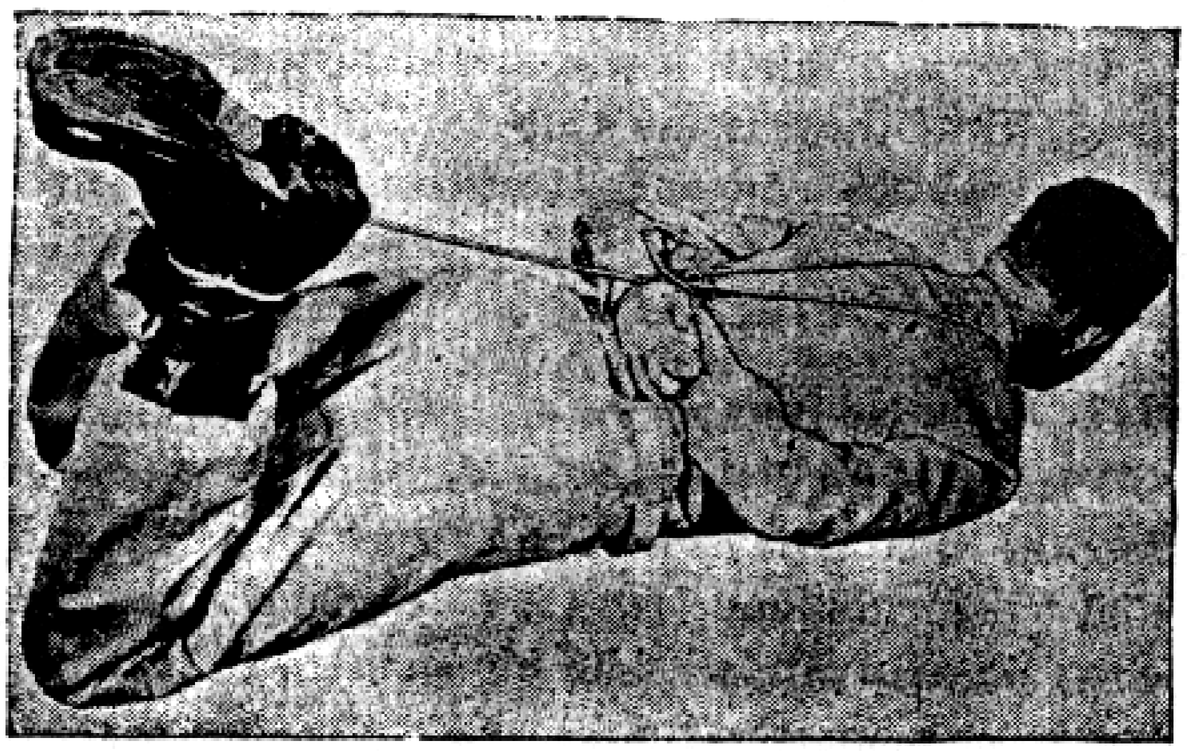

Figure 112. Hog tie.

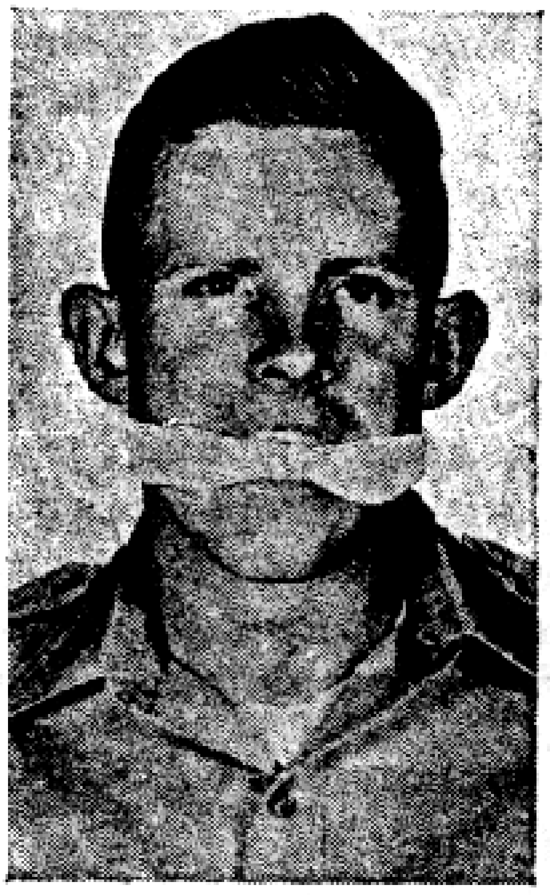

Figure 113. Handkerchief gag.

128. Stick

If a strip of cloth is not available, a stick can be used. Stuff the prisoner's mouth with a piece of turf. Force the stick between his teeth like a bit in a horse's mouth. Tie the stick with a piece of shoe string around his neck (fig. 114).

129. Adhesive Tape

Place several strips of tape across the prisoner's mouth. The tape should be at least one inch wide and five inches long (fig. 115). Stuffing a handkerchief or strip of cloth into his mouth will make the gag much more effective.

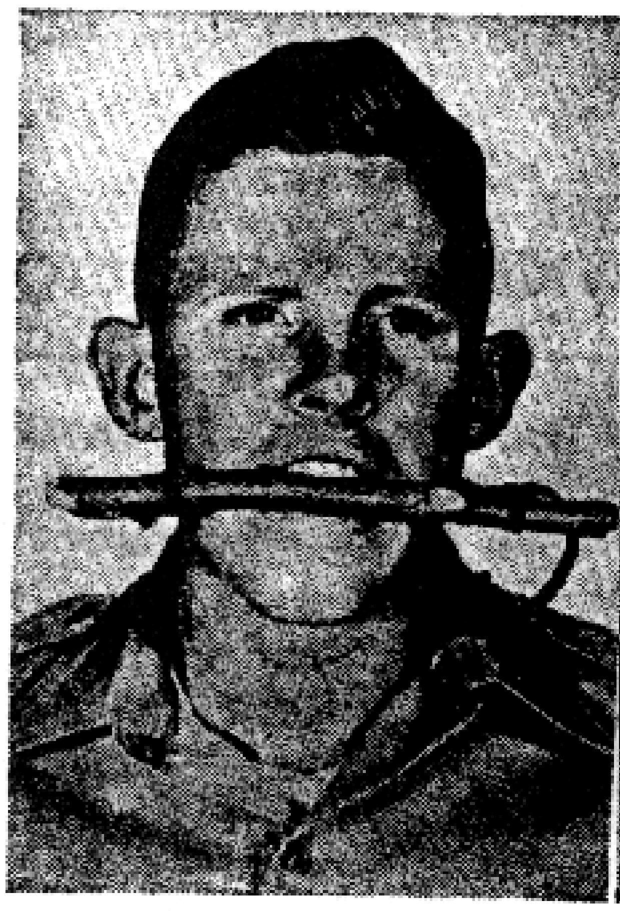

Figure 114. Stick gag.

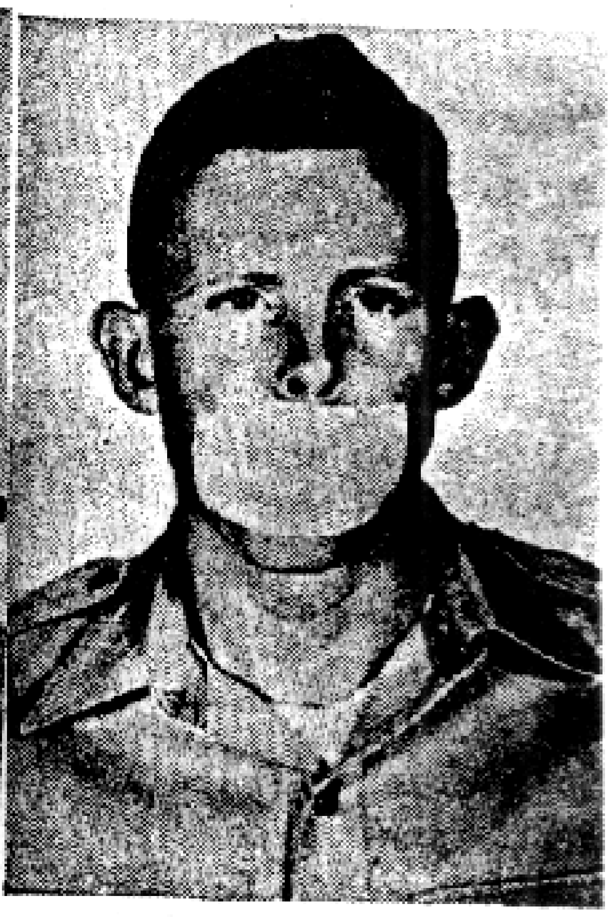

Figure 115. Adhesive tape gag.

CHAPTER 10

ADVICE TO INSTRUCTORS

Section I. THE INSTRUCTOR AND SAFETY PRECAUTIONS

130. The Instructor

The instructor should be in good physical condition and should be able to demonstrate all the maneuvers described in this manual. He must at all times display intense enthusiasm, vigor, and leadership qualities that will inspire the best efforts of the men being trained. He should train assistant instructors to closely supervise all practical work and to demonstrate new material.

131. General Precautions

The following safety precautions must be strictly followed during all training in unarmed combat—

a. Supervise all practical work closely and constantly. Never leave a class unsupervised.

b. Familiarize the students with each maneuver by complete explanation and demonstration before attempting any practical work.

c. During the learning stages, do not let the students get ahead of your instruction. This prevents accidents.

d. During the stages of learning and perfection of technique, the training partner offers no resistance. He should allow the maneuver to be freely executed.

e. Insure adequate space for all practical work. A space at least 8 feet wide by 8 feet long is needed for each pair of students.

f. Have the men empty their pockets before the practical work period and remove any jewelry, identification tags, etc.

132. Specific Precautions

The following precautions are applicable to the particular phases of training listed—

a. Vulnerable Points. Stress that only gentle blows are struck during the initial practical work. As students become more advanced, harder blows may be used. But students at all times must be cautioned against using excessive force, since serious injury could result.

b. Fall Positions, Throws, Holds.

- (1) Establish a signal that can be given by the individual student to stop the application of pressure when practicing holds. All students must know this signal, *particularly when practicing strangle holds.* This signal can, for example, be a clap of the hands or tapping your training partner.
- (2) Be sure all men are warmed up before doing any practical work.
- (3) Teach fall positions before conducting practical work in throws.
- (4) Caution the men to apply very light pressure until they become familiar with the hold.

c. Disarming.

- (1) While the men are learning bayonet disarming methods, keep scabbards on the bayonets and keep the bayonets firmly attached to the rifles.
- (2) Use tent pegs or bayonet scabbards to simulate knives in learning knife disarming.
- (3) Caution the men who are to be disarmed not to place their fingers in the trigger guards of their pistols or rifles while practicing disarming with these weapons.

Section II. CONDUCT OF TRAINING

133. Formations

a. Regulation physical training formations may be used for practice (FM 21-20). From the extended platoon formation, have the 1st and 3d ranks face the 2d and 4th ranks, so that each man will have a partner. Even numbered men do not uncover. It is recommended, when practicing throws, that twice the normal distance be taken between ranks.

b. For disarming methods, it is recommended that you use a formation of two concentric training circles or a formation that employs only two well-extended ranks. In forming the concentric training circle, pair the men off so that each will have a partner to work with.

134. Commands

a. Most of the maneuvers described in this manual can be divided into several steps or phases. To facilitate learning and to insure that the student learns each movement of an entire maneuver accurately, each maneuver is presented by phases.

b. For example, the right hip throw (par. 60) is a three phase maneuver. In the first phase, the student places his left foot in front of and slightly to the inside of his partner's left foot. At the same time, he strikes his partner on his right shoulder and grasps his clothing at this point. The command for this movement is PHASE ONE OF THE HIP THROW, MOVE. At the command MOVE, the student executes phase one and holds his position until given the subsequent command for the next movements. These commands are PHASE TWO (THREE), MOVE. When the students have become proficient in their movements, you can then work for speed. The phases of the maneuver are combined into a continuous movement by commanding HIP THROW, MOVE. At first, the maneuver is executed slowly. Students gain speed through constant practice.

c. Paragraph 92 explains the second counter against the long bayonet thrust. This disarming method is divided into three phases. For the first phase (par. 92*a*), the armed student is given the preparatory command LONG THRUST, and the unarmed student is given the preparatory command PARRY RIGHT. Since you want both students to halt their movements and remain in position for a subsequent command, you must command HOLD. The entire command for the first phase, therefore, is LONG THRUST, PARRY RIGHT, AND HOLD, MOVE. The next two phases of the movement are executed while the armed man is extended in the long thrust. The command for the second phase (par. 92*b*) is GROUND AND HOLD, MOVE. The command for the third phase (par. 92*c*) is DISARM AND HOLD, MOVE. The command for executing this disarming maneuver is DISARM FROM THE LONG THRUST, MOVE.

135. Exercise

a. Recommendations for Warm-up Exercises. Use combative exercises, grass drills, and tumbling exercises to warm up your men. The aggressive nature of these warm-up drills lend themselves to the spirit of hand-to-hand combat (FM 21–20).

b. Recommended Drill for Parry Exercise. It is important that your men be trained in the bayonet disarming parry movements before practicing the disarming methods. To do this, have the paired men assume their respective guard positions with the chin of the unarmed man 6 to 8 inches from the point of the bayonet. The armed man stands fast in the guard position during the entire exercise. The unarmed man parries the bayonet first to the right and then to the left, on command. As he parries to the right, he side-steps to his left oblique with his left foot, brings his right foot slightly to the rear of his left, and faces the side of the rifle. When he parries left, he side-steps with his right foot to his right oblique.

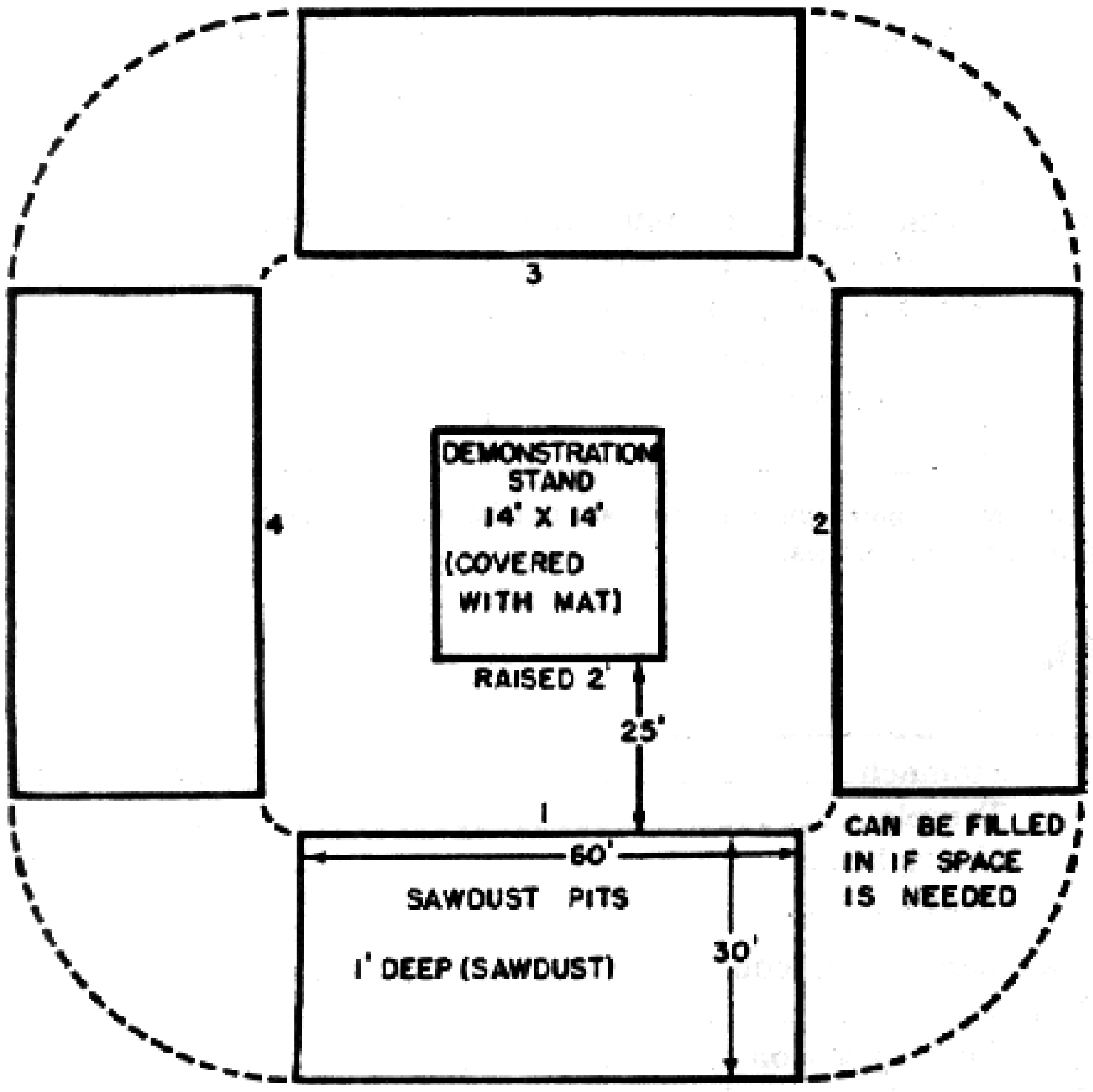
3
4
2
1
DEMONSTRATION STAND 14' X 14' (COVERED WITH MAT)
RAISED 2'
25'
60'
SAWDUST PITS
1' DEEP (SAWDUST)
30'
CAN BE FILLED IN IF SPACE IS NEEDED

Figure 116. The training pit should be large enough to allow maneuvering by the students.

Section III. THE TRAINING AREA

136. Training Pit

a. The most suitable area for teaching fall positions, throws, and counters is the sawdust pit. You can get sawdust easily at most stations. Figure 116 shows such an area. Each pit will accommodate twelve pairs of men. If you need additional room, fill in the area to the sides of each pit, as shown.

b. To construct a pit, either dig out 12 inches of ground or build a retaining wall of dirt about 12 inches high around the sawdust pit.

c. Place a raised platform, about 14 feet square, in the center of the pit area for demonstrations. Cover it with a removable mat. This platform is big enough to hold both the demonstrators and principal instructor during the demonstration.

d. The men gather around the platform to watch the demonstrations.

137. Other Areas

a. Any large grassy or sandy area is suitable for work in disarming methods and throws. Students should be taught fall positions before learning throws on a hard grassy area.

b. Classes in unarmed combat can also be conducted indoors. In this case, the floor and walls should be matted. The difficulty here is that only a small group of men can participate at one time, since an area eight feet square should be allotted for each two men.

138. Variation in Minimum Training Program

Periods eight and nine of the subject schedule include work in throws, falls, and escapes from basic holds. This time, however, may be spent in reviewing previous lessons, if the instructor thinks the students need review. The throws, falls, and escapes can be included in the physical training program.

Section IV. MINIMUM TRAINING PROGRAM*

139. Subject Breakdown

Period	Subject	Type	Area	General subjects department	
				Student equipment	References
1	INTRODUCTION, basic fundamentals attacking vulnerable points. STRANGLE HOLDS.	C, D, PE	Field	One tent peg per two students.	FM 21–150, chs. 1, 2, 3, 7.

2	Review Vulnerable Points and Strangles, silencing Sentries, HOLDS.	C, D, PE	---do-----	One tent rope and one steel helmet per two students.	FM 21-150, chs. 5 & 7.
3	Review PE Strangle Holds and Silencing Sentries. KNIFE ATTACK.	C, D, PE	---do-----	One tent rope, 1 tent peg or bayonet scabbard, and 1 steel helmet per two students.	FM 21-150, ch. 4.
4	Review Knife Attack, Bayonet Disarming.	C, D, PE	---do-----	One tent peg and 1 rifle w/bayonet and scabbard per two students.	FM 21-150, section I, ch. 8.
5	Review Bayonet Disarming, Knife Disarming.	C, D, PE	Field----	One tent peg and 1 rifle with bayonet and scabbard per two students.	FM 21-150, section II, ch. 8.
6	Review Knife Disarming, Pistol Disarming.	C, D, PE	---do-----	One tent peg and 1 wooden pistol per 2 students.	FM 21-150, section IV, ch. 8.
7	Review Pistol Disarming, Rifle Disarming.	C, D, PE	---do-----	One wooden pistol and 1 rifle per 2 students.	FM 21-150 section III, ch. 8.
8	Side Fall Position, Hip Throw, Reverse Hip Throw.	C, D, PE	Pits------	None-----------------	FM 21-150, ch. 6.
9	Over Shoulder Fall Position, Over Shoulder Throw, Escapes from Holds.	C, D, PE	---do-----	None-----------------	FM 21-150, ch. 6 & 7.
10	Prisoner Handling---------	C, D, PE	Field-----	One belt, 1 pair shoe strings, 1 rifle, 1 wooden pistol, one 15-foot rope per 2 students.	FM 21-150, ch. 9.

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*This program is used to give men a brief orientation in unarmed combat. Much more time must be spent to take men proficient. If more time is available, suggest the use of applicable portions of TF 19-1634, Personal Encounters.

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Explosives, Matches and Fireworks

by Joseph Reilly

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INDEX OF SUBJECTS 474

This book was undated but was printed about 1940. It is for the advanced chemist, which you may become if you apply yourself. Its tests and analysis of materials in explosives will give you the theoretical knowledge you will need to be an explosives manufacturer.

I eliminated the hundreds of distracting and irrelevant footnotes, referring to books printed in the 1930s back through the last century since they are unavailable.

EXPLOSIVES

MOST explosives consist either of a mixture of carbon compounds with compounds rich in oxygen, or of organic compounds such as nitro-compounds and nitric esters, which contain the oxygen necessary for their combustion. A smaller class of explosives includes substances which undergo exothermic decomposition. The materials to be tested comprise oxidising agents such as nitrates and chlorates, reducing agents such as carbon, sulphur and organic compounds; nitro-compounds, nitric esters and the raw materials required for their manufacture, solvents, stabilisers, and a variety of other ingredients. The increasing use of non-volatile solvents, such as centralite, and the production of smokeless, non-flash and non-hygroscopic explosives has extended the range of analytical tests in the examination of explosives.

This section deals mainly with chemical and stability tests.

A. INGREDIENTS AND RAW MATERIALS

I. NITRATES

(a) Potassium Nitrate

Mol. wt., 101·1; sp. gr., 2·109; M.P., 337°; decomp. at 400°; soluble in 100 parts water, 13·2 at 0°, 246 at 100°.

The nitre which reaches explosives factories is usually refined. For crude nitre see Vol. II., p. 420.

Moisture. A weighed quantity is heated in a platinum crucible until it just melts, cooled in a desiccator and again weighed. The moisture should not as a rule exceed 0·05 per cent. Limits ranging from 0·03 to 0·25 per cent. are specified in different countries.

Insoluble in Water. This is determined in the usual way and should be practically nil.

Chlorides. A qualitative test with silver nitrate is usually sufficient. If necessary, the turbidity is compared with that produced by a known amount of chloride. Specification limits vary from 0·005 to about 0·03 per cent. For the quantitative estimation, the silver chloride may be weighed, or the chloride may be determined by titration with silver nitrate, using potassium chromate as indicator.

Sulphates. These are estimated as barium sulphate and should not exceed 0·1 per cent. (as K_2SO_4).

Perchlorates. These may be present in appreciable quantity in conversion-saltpetre. The following method gives very accurate results: 20 g. of the sample is heated to 545° in a covered nickel crucible and maintained for an hour at this temperature in a Gilbert furnace or electric furnace, to reduce the perchlorate to chloride, which is then titrated with silver nitrate by Mohr's or Volhard's method. The chloride present in an unheated sample is deducted. Any chlorate or iodate present must also be allowed for. Lenze recommended heating for half an hour in a porcelain crucible at 580° to 600°. The first quarter of an hour is occupied in raising the temperature to the required point. At higher temperatures losses of chloride occur. Methods involving the addition of iron filings, manganese dioxide, sodium bicarbonate, etc., have been proposed, but appear to have no appreciable advantage. Leimbach has proposed a wet method depending on precipitation with nitron, after removing the nitrate and chlorate by heating with hydrochloric acid. Reduction of the perchlorate with titanous sulphate has also been recommended.

Specification limits from 0·1 to 0·3 per cent. are given; potassium nitrate containing nitrites under 0·5 per cent. did not increase the sensitiveness of gunpowder and synthetic nitrates were found to be as suitable as material prepared from Chili nitrates.

Chlorates. Traces of chlorate give a yellow colour when the saltpetre is added to concentrated sulphuric acid. This can be used roughly as a colorimetric method. Another sensitive test depends upon the formation of a blue colour by aniline hydrochloride in concentrated hydrochloric acid. Chlorates can also be reduced to chloride by zinc, iron, formaldehyde, sulphurous acid, etc. The chloride is then determined by filtration. In most specifications chlorates are excluded entirely. Sometimes 0·01 per cent. is admitted.

Saltpetre is also tested for carbonates, sodium, calcium and magnesium salts, and nitrites. These should be practically absent.

Potassium nitrate which is made from synthetic nitric acid, either by direct neutralisation with potassium carbonate, or through the sodium salt, is very pure and in general it suffices to test for moisture, insoluble matter, chloride and chlorate.

The moisture content is generally less than 0·1 per cent. and the impurities are present only in traces.

Estimation of Potassium Nitrate. Potassium nitrate is readily determined in gun-powder and allied mixtures by extraction with water. The nitrate may be determined, if necessary, by means of the Lunge nitrometer, or by precipitation with nitron.

(b) Sodium Nitrate

Mol. wt., 85·0; sp. gr., 2·26; M.P., 312°; soluble in 100 parts water, 73 at 0°, 175 at 100°; slightly soluble in alcohol.

The requirements of sodium nitrate for the manufacture of nitric acid are given in Vol. I., p. 470. Sodium nitrate for explosive purposes may be tested for moisture, insoluble matter, potassium, calcium, chloride, sulphate and sometimes iodide, iodate and perchlorate. The methods are in general similar to those for potassium nitrate. Sodium nitrate is now largely made from synthetic nitric acid. This gives a comparatively pure product, which may, however, contain small quantities of nitrite, chloride and soda. The nitrite may be tested for in small quantities by potassium iodide and starch, the estimation being made colorimetrically. Larger quantities may be estimated by titration with potassium permanganate.

(c) Ammonium Nitrate

Mol. wt., 80·0; sp. gr., 1·725; M.P., 169·6°; decomp. at about 200°; soluble in 100 parts water, 118 at 0°, 870 at 100°; slightly soluble in alcohol.

This salt is used very extensively in explosives. Owing to a number of disasters with ammonium nitrate explosives a great amount of research has been carried out on the use of this substance alone and in mixtures for explosive use. The material should be white or very slightly grey or yellowish. It should give a clear solution in water. The size of particles is generally specified. The moisture is estimated by drying in a vacuum over sulphuric acid for at least twenty-four hours ; if it is necessary to shorten the time by warming, the temperature should not exceed 70°.

Oils are sometimes present, being added to reduce the hygroscopicity. These may be estimated by extraction with ether or benzene. Nitrite should be absent, and there should be practically no acidity to methyl orange.

Pyridine and thiocyanate may be present in ammonium nitrate made from gas-works ammonia and should be avoided as far as possible. Thiocyanate is estimated colorimetrically. Ammonium nitrate made from sodium nitrate by double decomposition practically always contains sodium salts. The total ammonium nitrate content is determined by estimations of the ammonia and nitrate by the usual methods.

(d) Barium Nitrate

Mol. wt., 261·4; sp. gr., 3·23; M.P., 592°; soluble in 100 parts water, 5·0 at 0°, 34·2 at 100°.

Barium nitrate is used in certain explosives such as tonite, and in firework mixtures. It is tested for moisture, insoluble matter, neutrality, chloride, chlorate, sodium, calcium, and lead. On addition of slight excess of sulphuric acid and filtering, the solution should give only traces of residue after evaporation and ignition. The total barium is estimated by the usual methods. The nitrate is best estimated by reduction to ammonia. Barium nitrate may be readily estimated in mixed explosives by extraction with water and precipitation with sulphuric acid.

(e) Lead Nitrate

Mol. wt., 331·0; sp. gr., 4·41; decomp. at about 200°; soluble in 100 parts water, 36·5 at 0°, 127 at 100°; slightly soluble in alcohol.

Lead nitrate should dissolve in water without residue. On adding sulphuric acid, and filtering, the liquid should give practically no residue on evaporation and heating. Impurities are tested for as in barium nitrate.

II. Chlorates and Perchlorates

(a) Potassium Chlorate

Mol. wt., 122·55; sp. gr., 2·34; M.P., 370°; decomp. slightly above M.P.; soluble in 100 parts water, 3·3 at 0°, 56 at 100°; slightly soluble in alcohol.

Potassium chlorate should be pure white, free from smell and in a very fine crystalline condition. The degree of fineness is usually specified. The purity of the salt is important for explosive purposes, as impurities may lead to increased sensitiveness to shock and friction. The moisture is usually restricted to 0·2 to 0·5 per cent.

The aqueous solution should be neutral, and should give only traces of insoluble matter ; gritty matter such as sand is particularly to be avoided. The potassium chlorate should be practically free from chloride, perchlorate, nitrate, sulphate, carbonate and lead. Sodium, calcium and arsenic are sometimes tested for. Organic matter should be absent.

Bromate frequently occurs in appreciable proportions up to 0·5 per cent. and is to be avoided. It gives a blue colour with potassium iodide and starch in presence of dilute sulphuric acid ; chlorite and hypochlorite also react with starch iodide. Chlorate gives a similar coloration on longer standing. The bromate may be estimated quantitatively by addition of potassium iodide and dilute acid, and titrating back the free iodine with thiosulphate. Specification limits vary from 0·05 to 0·15 per cent.

Nitrates may be tested for by evaporating with a solution of brucine and oxalic acid in alcohol ; the presence of nitrate is indicated by a red colour.

Perchlorate is detected by addition of a 0·3 per cent. solution of methylene blue, which gives a violet precipitate with green fluorescence.

Estimation of Chlorate. The total chlorate may be estimated as follows, and should be at least 98·5 to 99 per cent.

(*a*) By ferrous sulphate. The chlorate solution is placed in a flask fitted with a Bunsen valve. A solution of 100 g. ferrous sulphate crystals and 100 c.c. conc. sulphuric acid in a litre of water is prepared, and 25 c.c. of this is added to the flask and boiled for ten minutes. After cooling, the excess of ferrous salt is titrated back with $N/2$ permanganate. It is desirable to add some manganous sulphate, as the hydrochloric acid formed may otherwise give rise to difficulty.

It is also recommended to titrate slowly. The reaction which takes place is as follows :—

$$6FeSO_4+KClO_3+4H_2SO_4 = 3Fe_2(SO_4)_3+KHSO_4+HCl+3H_2O.$$

(*b*) Iodometric method. The chlorate is heated with excess of hydrochloric acid, and the gas evolved is passed into excess of potassium iodide solution. The reaction is as follows :—

$$KClO_3+6HCl = KCl+3H_2O+3Cl_2.$$

The chlorine exists partly as lower oxides, but this does not affect the amount of iodine liberated. The chlorate is weighed and placed in a flask. Fuming hydrochloric acid is added, and the flask is quickly connected to the tube passing to the potassium iodide solution (1 : 10). After boiling off the chlorine, an excess of $N/10$ thiosulphate is added to the iodide solution and titrated back with iodine solution, using starch as indicator.

Other methods depend upon reduction of the chlorate with sulphurous acid, iron, etc., and estimation of the chloride formed, and upon precipitation as nitron chlorate. Methods for the detection of small quantities of chlorate have been given under potassium nitrate.

(b) Sodium Chlorate

Mol. wt., 106·45; sp. gr., 2·49; M.P., 248°; soluble in 100 parts water, 82 at 0°, 204 at 100°; soluble in alcohol.

Sodium chlorate is deliquescent and is relatively little used. It may be tested in the same way as potassium chlorate. Roman gives the following specification : sodium chlorate 99·5 per cent., sodium chloride 0·2, bromide 0·1 ; traces of heavy metals and alkaline earths ; no mechanical impurities ; no insoluble residue in water.

(c) Potassium Perchlorate

Mol. wt., 138·55; sp. gr., 2·52; M.P., 610°; soluble in 100 parts water, 0·7 at 0°, 18·7 at 100°.

Potassium perchlorate forms a white, crystalline solid, which is very sparingly soluble in water. It is not hygroscopic. It should be in a fine state of subdivision. It is much more stable than the chlorate ; it is not readily decomposed by acids, and is reduced with difficulty in solution. It should be free from sodium salts.

Chlorides and sulphates should be present only in small proportion. Chlorate should be present only in traces. This may be tested for qualitatively by warming with hydrochloric acid. A smell of chlorine indicates the presence of chlorate. The chlorate may be estimated colorimetrically by the yellow-brown colour produced on warming with hydrochloric acid and potassium iodide.

Potassium perchlorate may be detected in mixtures by the methylene blue reaction (see under Potassium Chlorate). It may be estimated quantitatively by heating, as described under Potassium Nitrate, or by nitron ; also by precipitation as methylene blue perchlorate and titration of the excess of methylene blue with picric acid. It can also be reduced with titanous sulphate or chloride.

Sodium perchlorate contains a higher proportion of oxygen, but is not suitable for use on account of its hygroscopicity.

(d) Ammonium Perchlorate

Mol. wt., 117·45; sp. gr., 1·87; soluble in 100 parts water, 12·4 at 0°, 88·2 at 100°; slightly soluble in alcohol and acetone.

The examination is similar to that of the potassium salt. Absence of chlorate is of special importance. Chlorides and sulphates should not exceed about 0·5 per cent., ash 0·5 per cent., and moisture 0·25 per cent. The ammonium perchlorate content should be at least 99 per cent.

III. INGREDIENTS OF GUN-POWDER

(a) **Potassium Nitrate** (see p. 1).

(b) Sulphur

At. wt., 32·06; sp. gr., 2·06 (rhombic); melts at 112-119°; boils at 444·5°; insoluble in water; soluble in many organic solvents, especially carbon disulphide (100 parts dissolve 37 parts sulphur at 15°).

For explosive purposes finely powdered roll sulphur is used. It must be free from acid. The moisture is estimated by drying in a vacuum or by warming, but a temperature of 70° should not be exceeded. The loss of weight should not be more than 1 per cent. The residue on burning off the sulphur should not exceed 0·15 per cent. Some specifications permit up to 0·5 per cent. The residue should be free from sand.

Arsenic is indicated by a bright yellow or reddish colour, and may be estimated by warming 5 g. of sulphur with 100 c.c. ammonia to 50°–60° for fifteen minutes, filtering, acidifying the liquor, and treating with hydrogen sulphide. There should be no weighable precipitate. Alternatively, a titration method with silver nitrate and potassium chromate may be used.

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Sulphur may be extracted from mixtures by freshly distilled carbon disulphide. It may be determined by evaporating at least three times with strong *aqua regia* to convert it to sulphuric acid, and precipitating with barium chloride.

(c) Charcoal

The examination is mainly physical. Good charcoal should have a deep black, velvety fracture, low density, and should be soft and easily rubbed to powder. It should not scratch copper and should ring well when struck. Charcoal from different woods may be recognised by the pith, which is round and brown for dogwood, black and round for willow, triangular for alder, and small, round and black for hazel wood. Birch and poplar are also sometimes used. Brown charcoal is recognised by its colour. The moisture is estimated by heating at 100° and should not exceed 4 per cent. The carbon content is sometimes determined, and ranges from about 70 to 75 per cent. The ash is determined in the usual way. It should not contain gritty matter.

IV. VARIOUS INGREDIENTS

(a) Graphite

Graphite is used for coating powders. It must give an adherent, uniform coating and for this purpose must be very finely ground. It should have a uniform grey colour, and a smooth feel when rubbed. Pure graphite has a specific gravity of 2·255. It should be free from acid. The ash is determined in the usual way, but vigorous heating is necessary to burn off the graphite. The residue may amount to 15-25 per cent. Silicates should be absent. Volatile matter is estimated by heating in an atmosphere of nitrogen. The carbon content may be estimated by combustion in a current of oxygen, and determination of the carbon dioxide. Sulphur is determined by heating with magnesia and sodium carbonate, then with ammonium nitrate or sodium peroxide to convert to sulphate, which is estimated as barium sulphate.

(b) Aluminium

At. wt., 27·0; sp. gr., 2·70; M.P., 658°.

Aluminium is used in a finely powdered condition or as flake in explosive mixtures. The degree of fineness and bulk density are usually specified. The aluminium must be as free as possible from oxide and from impurities which promote oxidation on storage. The specification limits for aluminium content range from about 92 to 98 per cent. Iron is frequently present up to 0·5 or 1 per cent., and small quantities of zinc and copper are met with (0·1 to 0·2 per cent.). The copper content should be as low as possible, since larger amounts make the aluminium very reactive towards nitrates. Silicon is also found up to about 0·5 per cent. Oily matter is often present up to 0·3–0·5 per cent. Soap should not be present in more than very small proportions. The loss of weight on heating to 100° for an hour should not exceed 0·25 per cent. For the determination of the aluminium content, the metal is dissolved in hydrochloric acid or potassium hydroxide solution, and the hydrogen evolved is measured, or determined by a gravimetric method. Other methods depend upon reduction of ferric sulphate, and on conversion of the aluminium to chloride which is then distilled off in a current of hydrogen chloride.

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(c) Magnesium

At. wt., 24·32; sp. gr., 1·74; M.P., 650°.

Magnesium is used in a powdered form. The degree of fineness is usually specified. The magnesium should be as free as possible from oxide and from other metals. Small quantities of iron are usually present (0·5 to 1 per cent.). Copper, aluminium, manganese, zinc, lead, calcium and silicon may be present in traces. Gritty matter is to be avoided, and oil or fat should be present only in traces. The content of metallic magnesium is estimated by measuring the hydrogen evolved on treatment with hydrochloric acid (*cf.* aluminium).

(d) Paraffin Wax

This should be white and as transparent as possible. It should have no taste or smell. It must be free from mechanical impurities and acidity, and must dissolve completely in acetone or carbon disulphide. On ignition it should give very little ash. The melting point is not very definite. It is generally specified for the special purpose for which the paraffin wax is required. The determination of the setting point is sometimes preferred.

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The apparatus for this test consists of a thermometer of suitable range and a small glass cup with a hole in the bottom. About 0·2 g. of the paraffin or mineral jelly is placed in the cup, which is then fitted on to the bottom of the thermometer bulb. On slowly heating the thermometer and cup, the temperature at which drops of melted paraffin fall away from the cup is noted.

(e) Colophony

This is a brittle, vitreous material of yellow to brown colour and sp. gr. 1·07 to 1·08. It has very little taste or smell. It is insoluble in water, but dissolves in alcohol and most other organic solvents. It has a very indefinite melting point. On heating it softens at 70° and becomes molten at about 108°. It should not lose more than 0·2 per cent. on heating at 100°.

(f) Castor Oil

Castor oil is used to reduce the sensitiveness to friction. It is also a waterproofing agent and prevents the recrystallisation of potassium chlorate. The oil is colourless or pale yellow, highly viscous, and somewhat lighter than water (sp. gr. 0·96 to 0·97 at 15°). It is optically active and has a refractive index of 1·4773. It is miscible with absolute alcohol and many other organic solvents, but is insoluble in petroleum-ether and benzine, and incompletely soluble in 90 per cent. alcohol. A mixture of 10 c.c. of the oil and 50 c.c. of alcohol of sp. gr. 0·829 at 17·5° should give no turbidity. On shaking with an equal volume of 50 per cent. nitric acid it should not blacken. The acidity is determined by dissolving in alcohol and titrating with alkali. The saponification number is estimated in the usual way. Colophony can be detected by dissolving in acetic anhydride and adding a drop of concentrated sulphuric acid (violet or red colour). Paraffin wax may be detected by saponifying 5 g. of the oil with 20 c.c. of a solution of 40 g. sodium hydroxide in 93 c.c. water and 500 c.c. glycerol. The hot liquid is then added drop by drop to 50 c.c. of methyl alcohol. In absence of paraffin wax the liquid remains clear on cooling; 2 per cent. of wax causes the liquid to become cloudy, and after a time gelatinous. The refractive index and viscosity are also made use of to ensure absence of impurities.

(g) Kieselguhr

Kieselguhr is used for the manufacture of dynamite. It consists of diatoms which are capable of absorbing considerable quantities of nitroglycerine or other liquids. It is obtainable commercially in fairly pure condition, but is subjected to calcination at the dynamite factory before mixing with the nitroglycerine. It should be white or faintly reddish and should have a smooth feel when rubbed between the fingers. It should be as free as possible from sand, acid, and organic matter. The water content should not exceed 1 per cent. Sand may be separated by shaking with water and allowing to settle quickly. The separation is facilitated if the kieselguhr is first broken down by boiling with strong alkali. The absorptive capacity is ascertained by mixing weighed quantities of nitroglycerine and kieselguhr, filling into a cavity in a wooden block and pressing with a wooden plunger by means of a definite weight. The lower end of the cavity is open and is covered with a piece of parchment paper. The amount of nitroglycerine which is pressed out is an inverse measure of the absorptive capacity. A rough indication is also given by the amount of nitroglycerine necessary to make the kieselguhr appear wet; a good kieselguhr should take up at least four parts.

(h) Wood Meal

Wood meal should be free from acid and foreign substances, especially sand and metallic particles. No chemicals should be used in the manufacture, and bleaching agents should be avoided. The degree of fineness is generally specified. Larger fragments of wood should not be present.

Limits for the moisture content range from 5 to 10 per cent. The ash should not exceed 0·5 to 1·0 per cent. Resin is determined by extraction with ether. Extraction with alcohol removes tannin, etc. These extracts should be very small in quantity. Wood meal contains small quantities of water-soluble matter, which should be taken into account in the estimation of wood meal in dynamite, etc.

The cellulose content may be estimated by treatment with caustic soda and chlorine.

Wood meal should absorb liquids readily. Thus it should retain 60 to 70 per cent. of nitroglycerine without exudation. The combustibility is tested by mixing one part of wood meal with 3 parts of potassium nitrate and burning in a lightly covered crucible. The residue should not exceed 10 per cent. The rapidity of burning is measured by filling some of the mixture into a groove in a sheet of metal and igniting at one end.

The bulk density is measured by adding the wood meal little by little to a 100 c.c. measuring cylinder, which is knocked on the table after each addition to shake the wood meal down. The quantity which fills 100 c.c. is weighed.

Wood meal may be detected in mixtures by the microscope or by the phloroglucinol test. One gram of phloroglucinol is dissolved in 15 c.c. of alcohol, and 10 c.c. of syrupy phosphoric acid is added. A little of the meal is rubbed with 0·5 c.c. of this reagent in a porcelain dish. Wood fibres show a rose colour changing to carmine. Apart from wood meal other forms of meal (corn, potato) are similarly used.

(i) Chlorides, Oxalates, Carbonates

Sodium and potassium chlorides are much used in industrial explosives. They are generally obtainable in a sufficiently pure condition. They should be free from hygroscopic impurities. The degree of fineness is of importance and is generally specified; large particles should not be present.

The oxalates of potassium, sodium, and ammonium should be pure white, and free from mechanical impurities. The two former should be free from acidity and alkalinity; ammonium oxalate may develop slight acidity by hydrolysis and the litmus paper tends to change colour on drying. The sodium salt is anhydrous, the two others have water of crystallisation. They should dissolve practically completely in water and should be free from chlorides, sulphates and heavy metals. The ammonium salt should leave no residue on ignition. Oxalates are readily detected as the calcium salt and the purity can be determined by titration with permanganate.

Sodium carbonate is occasionally used as a stabiliser in blasting explosives. It should be of 98 to 99 per cent. purity, and should contain only traces of chlorides, sulphates, and ammonia. It should dissolve in water without residue.

Sodium bicarbonate should be finely powdered, and should dissolve completely in water. Carbonates of other metals should be present only in traces, and chlorides and sulphates should also be practically absent. The purity should be at least 99 per cent.

Calcium carbonate should be in a very finely dissolved condition; the state of subdivision is usually specified. It should be practically free from calcium oxide or hydroxide and from salts of metals other than calcium.

(j) Cuprene

For gun-powder required for burning under reduced pressure, Grimwood recommends the use of cuprene, a polymerised product from acetylene. This may be used to replace either wholly or in part the charcoal of gun-powder. Even at very low pressures the rates of burning are not appreciably altered when this substance is used.

V. STABILISERS

(a) Camphor

$C_{10}H_{16}O$; mol. wt., 152·1; sp. gr., 0·985 at 18°; M.P., 180°; B.P., 209°; soluble in water 0·1 per cent.; soluble in organic solvents.

Apart from natural camphor, the synthetic material is now made in considerable quantities. Natural camphor is optically active, the synthetic product is the racemic form, and is inactive except for small quantities of impurities.

On heating, camphor should not begin to sinter below 173° and should not melt below 175°. On sublimation it should leave practically no residue (0·1 per cent.). It is tested for acid by dissolving in alcohol, precipitating with water and testing the solution. The presence of water is indicated by turbidity on dissolving in petroleum ether. Camphor gives a yellow to brown solution in concentrated sulphuric acid, according to the organic impurities present.

Crane and Joyce recommend for the determination of the purity of camphor—

(1) Determination of residue on sublimation.
(2) Sp. gr. of a 10 per cent. solution in benzene.
(3) Optical rotation (for natural camphor).

(b) Diphenylamine

$(C_6H_5)_2NH$; mol. wt., 169·1; sp. gr., 1·159; M.P., 54°; B.P., 302°; practically insoluble in water; soluble in most organic solvents.

The compound should be white or pale yellow. It should melt at 52° to 54° and should yield practically no insoluble residue in ether or alcohol. It should also give a clear solution in pure sulphuric acid (a blue colour indicates the presence of nitrate). It should have no unpleasant smell. Aniline bases should be present only in traces (0·001 per cent.). These may be tested for by bleaching powder.

In the detection of diphenylamine the nitric acid reaction is used. The quantitative estimation is described under Smokeless Powder (p. 53).

(c) Substituted Ureas

Symmetrical diethyl- and dimethyldiphenyl-urea are known as Centralite I and II respectively. They are used as stabilisers, as they absorb the oxides of nitrogen, formed by the decomposition of nitric esters.

Centralite I melts at 79° and Centralite II at 121·5°. They sublime above the melting point. They are very sparingly soluble in water, but dissolve readily in alcohol and ether. They should be almost colourless and free from aniline, volatile substances, chlorides and mechanical impurities. They should give clear solutions in alcohol and should give no residue on incineration.

Asymmetric diphenylurea (acardite) also belongs to this class of compounds. It melts at 189°. On boiling with sodium hydroxide solution it is hydrolysed to diphenylamine which can be driven over by steam. The symmetrical derivative melts at 235°. It is not volatile in steam.

Substituted urethanes are also used as stabilisers.

The estimation of centralite, etc., is dealt with under Smokeless Powders (p. 53).

(d) Mineral Jelly

This is used principally for the manufacture of cordite. It should be free from foreign matter, scales and particles, and should have a flash point of at least 400° F. (205° C.) and a sp. gr. of not less than 0·87 at 100° F. (37·8° C.). It should not lose more than 0·2 per cent. in weight on heating for 12 hours on a water-bath and should be practically free from mineral matter. The acidity may be tested by dissolving in ether, allowing to settle and titrating a measured portion of the liquid with alcoholic potassium hydroxide. The mineral jelly should be practically neutral. Mineral jelly has no definite melting point, It is important that the mineral jelly shall not have been melted for two or three days before testing.

Mineral jelly is practically insoluble in a mixture of 4 parts methyl alcohol and 1 part water, and this is made use of in the separation of mineral jelly from nitroglycerine, etc.

Camphor, substituted ureas and triphenyl phosphate are sometimes used to modify the rate of burning of gun-powder. Phthalides are claimed to have advantages over centralite in certain smokeless powders.

VI. NITRATION ACIDS

(a) Nitric Acid

The methods of testing are given in Vol. I., p. 489. These include the total acidity, lower oxides of nitrogen, sulphuric acid, chlorine, iodine and mineral matter. The lower oxides are usually restricted to 1 per cent. (as NO_2). Chlorine should not exceed 0·03 per cent. and mineral matter 0·01 per cent. Nitric acid may contain traces of tetranitromethane and of chloronitromethanes, which are liable to find their way into nitroglycerine and lower the heat test.

(b) Sulphuric Acid and Oleum

Methods of testing are given in Vol. I., pp. 416, 456.

(c) Mixed Acids and Spent Acids

Mixed acids for nitroglycerine manufacture should be as free as possible from suspended matter, such as sulphates of iron or lead, as these may delay the separation.

In the spent acids the nitric acid content is lower and the water content higher than in fresh mixed acids. They also contain organic matter which differs according as the acids are from nitrocellulose, nitroglycerine, or nitroaromatic compounds. The presence of these and of muddy suspensions gives rise to some difficulties in analysis. In the determination of nitrogen by the nitrometer method allowance must be made for dissolved nitroglycerine ; this may be determined by extraction with ether or chloroform and evaporating gently. The estimation of nitrous acid may also be affected by organic matter. Raschig avoids this by adding potassium iodide and titrating the liberated iodine in an atmosphere of carbon dioxide.

Webb gives the following method for the waste acid from nitroglycerine manufacture : A sample is maintained at 120° in a calcium chloride bath for 20 minutes, and the nitric acid is driven off by a current of steam. The residual solution contains sulphuric and oxalic acid. The latter is estimated by titration with permanganate at 60° and the sulphuric acid is determined by titration with alkali and methyl red after addition of 1 c.c. of 3 per cent. hydrogen peroxide for each 5 c.c. of permanganate previously used up. This is to destroy organic matter. It is necessary to calculate from the permanganate titration the amount of sulphuric acid which is used up in the reaction between permanganate and oxalic acid and to add this to the sulphuric acid estimated by the alkali titration. The nitric acid is determined by Lunge's method. Dissolved nitroglycerine is oxidised by potassium bichromate, and the excess of bichromate estimated by potassium iodide and thiosulphate.

VII. CELLULOSE

(a) Cotton Cellulose

The cotton cellulose used for the manufacture of nitrocellulose must be as free as possible from husks, seeds, paper, dust, coal, sand, woven and twisted masses, and must not contain residues of soda or bleach. It should not be acid. The moisture is determined by heating 5 g. at 103° to 105° to constant weight and may amount to 7 to 8 per cent. The ash should not exceed 0·5 to 1 per cent. Oily matter is determined by extraction with ether and is generally restricted to 0·4 to 0·6 per cent. Starch should be absent or present only in traces.

Alpha-cellulose. Ten g. of cellulose is broken down by kneading in a mortar with 50 c.c. of 17·5 per cent. sodium hydroxide solution free from carbonate. After 30 minutes 50 c.c. of water is added, and the cellulose is filtered and washed. The mass is wetted with hot dilute acetic acid, again washed, and dried. The residue represents the alpha-cellulose, after deducting the weight of the ash.

Reducing Substances. These are tested for by the " copper value." In the method of Schwalbe the cotton is boiled with Fehling's solution, prepared by adding copper sulphate solution to alkaline Rochelle salt. In Braidy's modification, which is stated to give more consistent results, 2·5 g. of very finely divided air-dry cotton is treated with a mixture of 5 c.c. of 10 per cent. copper sulphate (cryst.) and 95 c.c. of an almost saturated solution of sodium carbonate and bicarbonate (350 g. soda crystals and 50 g. bicarbonate made up to 1 litre). The cotton is immersed by means of a rod and the air bubbles are allowed to escape ; the flask is then surrounded with boiling water for exactly three hours. The contents are filtered off on an asbestos filter and washed first with dilute sodium carbonate solution and then with water. Then the residual cuprous oxide is dissolved by treatment with a solution containing 100 g. of iron alum and 140 g. of concentrated sulphuric acid per litre. Two such treatments usually suffice. The filter is then washed with 2 N-sulphuric acid ; the combined filtrate and washings are titrated with $N/25$ potassium permanganate solution. According to Brissaud the test is affected by air.

Alkali-soluble Substances. The methods vary somewhat in detail. The following conditions are given by Landon. Five g. of dried cellulose is placed in a litre flask, and 300 c.c. of 10 per cent. potassium hydroxide solution (or the equivalent of sodium hydroxide) added. The hydroxides should be free from carbonate. The mixture is boiled under a reflux condenser for three hours. The ebullition should be as regular as possible ; fragments of porcelain may be added to prevent bumping, and should be removed afterwards. The mixture is poured into a litre of cold water ; the flask is rinsed carefully and acetic acid is added to destroy combinations of cellulose and alkali. The cellulose is filtered, washed with hot water and dried. The loss of weight represents the alkali-soluble material. Landon gives a limit of 3 per cent. Part of the alkali-soluble material can be reprecipitated with acid. This is known as wood gum. The following method is in use : 15 g. of the dried cellulose is immersed in 300 c.c. of a 5 per cent. solution of sodium hydroxide, and allowed to stand for twenty-four hours at 18° to 20° with frequent shaking. The liquid is filtered off and 100 c.c. mixed with 200 c.c. of alcohol (92·5 per cent. by weight). A little phenol phthalein is added and then 9·5 c.c. of hydrochloric acid (1·19) to neutralise most of the alkali. The neutralisation is completed with normal acid, and a further 5 c.c. of acid is added. After twenty-four hours the precipitate is collected on a tared filter paper or in a Gooch crucible, washed with alcohol and ether, dried at 100° and weighed.

Cotton is also tested for ligneous matter by absorption of dyes (fuchsine, methylene blue, malachite green) and for the viscosity of its solution in cuprammonium liquor. Gabillion gives the following figures for various cottons :—

Moisture, 4·5 to 6·0 ; ash, 0·1 to 0·25 ; fats, 0·1 to 0·25 (maximum) 0·8 ; iron, 0·008 ; insoluble in H_2SO_4, 0·1 to 0·5 ; alpha-cellulose, 99 per cent. ; copper number (unbleached) 0·07 to 0·10, (moderately bleached) 0·1 to 0·2, (strongly bleached) 3 to 4 ; potash number, 2.

(b) Wood Cellulose

Wood cellulose which is to be converted to nitro-cellulose must be in a form in which it can be readily dipped into the nitration acids and must be highly absorbent to permit of the penetration of the acids. It should be practically free from acidity and alkalinity, and from any residual chlorine from the bleaching process.

The moisture is estimated by heating 5 g. of the cellulose to 103° to 105° to constant weight. It is desirable to dry the cellulose partially at a lower temperature, otherwise some charring may take place at 105°. The dried cellulose should be allowed to cool in a stoppered weighing bottle, as it reabsorbs moisture very readily. Limits of 6 to 8 per cent. are specified.

The ash is determined in the usual way, taking 5 to 20 g. of material and finishing at a dull red heat. If calcium sulphate is present in quantity, it may be reduced ; in this case the cellulose may be first destroyed with nitric acid.

Fats and resins are determined by extraction with ether. Figures up to about 1 per cent. are given. Extraction with alcohol is sometimes also included. The method of determination of alpha-cellulose is given under Cotton (p. 16). Alkali dissolves xylan together with some oxycellulose, etc., and on neutralisation a mixture of substances is precipitated which is designated as wood gum. The method of estimation is given under Cotton Cellulose (p. 16). The figure obtained on neutralisation is known as the neutral wood gum number. Excess of acid gives a somewhat lower figure (acid wood gum). Figures of 5 to 8 per cent. are given for the neutral wood gum. It is to be observed that the precipitate readily carries down a considerable proportion of sodium chloride from solution ; this should be estimated and deducted from the total.

Pentosans are estimated by conversion to furfural. This is effected by distillation with dilute hydrochloric acid. Oxycellulose and other constituents of wood cellulose are also stated to yield small quantities of furfural. Methyl pentosans similarly yield methyl furfural. The wood cellulose is distilled with 12 per cent. hydrochloric acid until no more furfural is evolved. The furfural is then determined by precipitation with phloroglucinol. This gives a phloroglucide which can be washed, dried, and weighed.

According to Heuser and Boedeker, furfural = (phloroglucide + 0·001) × 0·571, and pentosan = furfural × 1·375.

A more expeditious volumetric method is given by Powell and Whittaker. 0·5 to 0·8 g. of material is distilled with 12 per cent hydrochloric acid until the distillate gives no more pink colour with aniline acetate. The apparatus used for the distillation should have all-glass connections. Into each of four well-stoppered bottles is pipetted 25 c.c. of standard sodium bromide-bromate (approx. $N/10$). To two of the bottles are added 200 c.c. of the above distillate, and to the others 200 c.c. of 12 per cent. hydrochloric acid. After standing for an hour in the dark, about 10 c.c. of 10 per cent. potassium iodide solution is added, and the iodine is titrated with $N/10$ thiosulphate. The difference between the blank and the test titration is a measure of the furfural. One g. mol. furfural is found to react with 4·05 g. atoms of bromine. According to Schwalbe, Kraftcellulose gives the highest pentosan content (7·6 to 9·3 per cent.) ; next comes unbleached soda cellulose with 5·9 to 7·7 per cent. Sulphite cellulose gives 3·3 to 4·6 per cent.

The copper value is used for the estimation of reducing substances (mainly oxycellulose). The method is given under Cotton Cellulose (p. 16). It is stated that pentosans and other constituents of wood cellulose also react to some extent. Hydrocellulose is formed by the action of acids on cellulose. On further hydrolysis with acid and neutralisation, it reduces Fehling's solution. Estimations of the hydrocellulose are not usually included.

Lignin presents considerable difficulties, as the constitution is unknown and definite quantitative reactions are not available. It contains hydroxy, acetyl, and methoxy groups. It can be acetylated and nitrated. Numerous colour reactions have been suggested. The commonest of these is the phloroglucinol reaction. A solution of 1 g. phloroglucinol in 50 c.c. alcohol is mixed with 25 c.c. conc. hydrochloric acid. This gives a red colour with lignin. It is important that the solutions be freshly mixed. It is sometimes specified that the cellulose shall not give more than a faint rose colour. Another test in common use is to dissolve 0·02 g. wood cellulose in 5 c.c. of conc. sulphuric acid and allow to stand for an hour. This gives a brown colour. The determination of the methoxy-group by the Zeisel method is sometimes used as a quantitative test, but the reaction is also given by methyl pentosans.

The wood cellulose may also be examined for viscosity in cuprammonium solution. To ascertain whether wood cellulose absorbs nitration acids readily, about 1 g. is pressed together lightly by hand and thrown on to a mixed acid containing 20 to 25 per cent. nitric, 70 to 60 per cent. sulphuric and 10 to 15 per cent. water. The cellulose should sink within one minute. On nitration it should neither become pappy nor become stiff through parchmentising. The following limits are given by Scharrnbeck. With the exception of the moisture estimation the percentages are calculated on the dry material :—

	Per cent.
Moisture	7·0
Ash	0·6
Wood gum (sulphite cellulose)	5·0
,, ,, (soda cellulose)	6·0
Chlorine—faint opalescence with $AgNO_3$	...
Alkali—faint red colour with phenolphthalein	...
Soluble in alcohol	0·5
Lignin—faint red with phloroglucin reagent	...

VIII. POLYHYDRIC ALCOHOLS

(a) Glycerine

Glycerol, $C_3H_5(OH)_3$; mol. wt., 92 ; sp. gr., 1·262 ; B.P., 290° ; miscible with water and alcohol ; insoluble in ether.

Pure glycerine is a colourless viscous liquid. The commercial product as used for dynamite is yellow to brownish in colour, and has usually a faint caramel-like odour when rubbed between the hands.

According to Crosfield glycerine for explosives manufacture must be a distilled product as free as possible from water and containing at least 98 per cent. glycerol. Its specific gravity should be not less than 1·262 (15·5°/15·5°). It should be free from lead, calcium, fatty acids, sugars and decomposition products of glycerol (acrolein, etc.) and should not contain more than traces of arsenic, iron and chlorides.

The glycerol content may be determined, if required, by acetylation, or by oxidation with dichromate.

The water content may be approximately estimated by heating in a weighing bottle with a loose stopper at 90°. Some evaporation of glycerol takes place; the heating should be continued until the successive losses are very small and approximately constant. The total loss is corrected for the loss of glycerol. Distillation with trichloroethylene has also been proposed.

Reducing substances may be detected by addition of silver nitrate and allowing to stand in the dark for fifteen minutes; Fehling's solution should give no reduction on standing for twelve hours in the dark.

The organic and inorganic residues are determinated by gradually evaporating 25 g. and completing the evaporation in an air bath at 160°. A little water should be added to the residue from time to time to prevent it from becoming too thick. The residue is weighed, and then ignited to ascertain the percentage of ash. The former should not exceed 0·25 and the latter 0·05 to 0·10 per cent.

Acidity and alkalinity are tested for in the usual way, after diluting the glycerine with two volumes of water. The glycerine should be practically neutral.

Fatty acids are estimated by diluting with an equal volume of water, extracting with ether, washing the ethereal solution several times with water, evaporating off the ether, and drying at 70°. No more than traces should be present.

For the determination of saponifiable matter, 100 g. of the sample is weighed out in a flask, 200 c.c. of boiled distilled water and 30 c.c. of $N/1$ sodium hydroxide are added; the whole is maintained at 100° for an hour and titrated.

Sugar and gums are shown by darkening on shaking with concentrated sulphuric acid. Small quantities of polyglycerines may be present, but these do not greatly affect the explosive properties of the nitroglycerine. They raise the specific gravity somewhat, and may therefore cause a glycerine containing a little water to have the correct specific gravity. Glycerine obtained by fermentation contains traces of trimethylene glycol. This gives a dinitrate which is stated to be as stable as nitroglycerine. Albuminous matter is tested for by lead acetate.

The nitrogen content should not exceed 0·3 per cent. Other tests include sulphides, sulphates, sulphites, thiosulphates, chlorides and arsenic. An important test is the ***behaviour on nitration.*** A mixture of 1 part by weight nitric acid (sp. gr. 1·50) and 2 parts sulphuric acid (sp. gr. 1·84) is placed in a beaker, which is held in the hand in a pail of cold water and kept continuously in motion. Mixed acid from the factory

may also be used. The temperature is maintained at 12° to 15° and the glycerine is allowed to flow in slowly. One part of glycerine to eight parts of mixed acid are suitable proportions to employ. Overheating is dangerous and the temperature must not be allowed to exceed 30°. When all the glycerine has been added, the mixture is cooled to 15° and brought into a separating funnel. It is important to observe the readiness with which the nitroglycerine separates from the acids. The separation should take place in ten minutes and should be clean and sharp without flockiness. The acid is carefully run off, and the nitroglycerine is washed repeatedly with water at 40° to 50°, then with lukewarm 2 per cent. sodium carbonate solution, and again with cold water, and measured in a burette. The yield is calculated from the specific gravity of nitroglycerine (1·60). A pailful of water should be held in readiness, in case it is necessary to drown the charge, by reason of the reaction becoming too vigorous. More accurate estimations are obtained by the use of special apparatus in which the nitration is carried out in a separating funnel cooled externally by water or by a freezing mixture. The stirring is effected by compressed air.

The theoretical yield is 246·7 per cent. of the weight of the glycerine. Naoum gives yields of 225 to 229 per cent.

Glycerol may be detected qualitatively in small quantities by colour reactions dependent on the formation of dihydroxyacetone.

(b) Diglycerine

$(CH_2OH\ CHOH\ CH_2)_2O$. Mol. wt., 166·0; sp. gr., 1·33; B.P., 245° to 250° C. (8 mm.); miscible with water; insoluble in ether.

On heating with small quantities of alkali to 250°-260° glycerine undergoes partial condensation to diglycerine which can be nitrated to diglycerine tetranitrate. This is one of the admixtures which are used to lower the freezing point of nitroglycerine. If the condensation has been carried out with glycerine of good quality, special testing may be confined to the specific gravity (approximately 1·286 at 15° for a content of 30 to 40 per cent. diglycerine). The nitration product gives a nitrogen content of 17·6 to 17·7 per cent. The trial nitration is carried out as described under glycerine. The tetranitrate forms emulsions somewhat readily on washing with water, and it is better to use sodium chloride solution. The tetranitrate retains moisture rather firmly and is more difficult to dry than nitroglycerine.

(c) Monochlorhydrin

$CH_2Cl\ CHOH\ .\ CH_2OH$. Mol. wt., 110·5; sp. gr., 1·338; B.P., 213°; miscible with water, alcohol and ether.

Monochlorhydrin consists mainly of α-chlorodihydroxypropane, but contains a small proportion of the β-isomer. Usually a mixture of monochlorhydrin and glycerine is obtained, together with some dichlorhydrin. Small proportions of diglycerine may also be present. Assuming that the monochlorhydrin has been prepared from glycerine of satisfactory purity, it is usually sufficient to ascertain the chlorine content and to ensure freedom from water, hydrochloric acid, and dichlorhydrin. Exact analysis of such a mixture is hardly practicable, but a trial nitration should be included, with a nitrogen determination of the product.

For the determination of chlorine, the mixture is first heated to 115° at 30 mm. pressure. This removes any water and dichlorhydrin. About 5 g. is weighed out and boiled for fifteen minutes with 10 c.c. of a 15 per cent. solution of sodium hydroxide in alcohol. The alcohol is evaporated off and a little water is added. This is boiled for a few minutes and the liquid is acidified with nitric acid and the chlorine determined. The value is somewhat too high owing to the presence of small quantities of dichlorhydrin.

(d) Ethylene Glycol

$CH_2OH\ CH_2OH$. Mol. wt., 62·0; sp. gr., 1·116 (15°); M.P., −11·5°; B.P., 194°; miscible with water and alcohol.

Ethylene glycol yields on nitration a dinitrate which is used in conjunction with nitroglycerine to lower the freezing point. It is a colourless liquid which is less viscous than glycerine. It resembles glycerine in its hygroscopicity.

It should contain 97 per cent. of ethylene glycol corresponding to a sp. gr. of 1·1074 (20°/4°) if water is the only impurity. The estimation of glycol can be carried out by the dichromate method as for glycerine. It should be free from mineral matter. The moisture content cannot readily be determined by direct heating on account of the greater volatility of ethylene glycol as compared with glycerine. Somewhat more accurate results may be obtained by distilling off a portion of the glycol until pure glycol passes over, then interrupting the distillation and determining the moisture approximately in the distillate by drying in a flat dish over phosphorus pentoxide with daily weighings until the rate of loss is constant. A correction must be applied for the ultimate constant loss.

A trial nitration is carried out as for nitroglycerine. The yield of nitrate may be depressed slightly by the presence of small quantities of higher homologues.

(e) Pentaerythritol

$C(CH_2OH)_4$. Mol. wt., 136·0; M.P., 253°; soluble in 100 parts water, 5·5 at 15°.

Pentaerythritol is used for the manufacture of the tetranitrate (Penthrit) which is a powerful explosive. It is a white or slightly yellowish crystalline compound. The melting point should be at least 220° to 230° and the compound should be completely soluble in water. According to Pushin, pentaerythritol undergoes allomorphic transformation at 185° and melts at 256°.

IX. AROMATIC HYDROCARBONS AND DERIVATIVES

(a) Hydrocarbons

Benzene and toluene are used for the manufacture of nitro-compounds; xylene is used to a minor extent. They are colourless liquids and should be completely neutral. They are insoluble in water, but mix with most organic solvents.

	Benzene	Toluene	Xylene
Melting point	5·2°	−94°	...
Boiling point	80·4°	110·3°	136° to 140°
Sp. gr. (20° C.)	0·879	0·866	0·868

In the distillation of benzene and toluene 90 per cent. should pass over within a range of 0·6°. For the distillation, 100 c.c. are placed in a distillation flask of about 200 c.c. capacity. This rests on a sheet of asbestos with a hole of 1 in. diameter in the centre. The flask is surrounded by an aluminium cylinder which reaches nearly to the level of the side tube. Xylene is a mixture of isomers of somewhat indeterminate boiling point.

Small percentages of *aliphatic hydrocarbons* are usually present. These should be as low as possible, as they do not undergo nitration. The specific gravity gives some indication of their presence, but a trial nitration is more certain. The hydrocarbon is nitrated to the mono-nitro-compound by a mixture of concentrated sulphuric acid and nitric acid (sp. gr. 1·42) at about 10° with vigorous stirring. The mixed acid is added very slowly to the hydrocarbon and the stirring is continued for an hour after all the acid has been added. The acid is drawn off, and the nitro-compound washed with water with addition of soda to render it alkaline. The separated oil is steam distilled until the drops sink in water. The water is separated and the oil is treated again with nitration acid in a graduated cylinder. The unnitratable hydrocarbons form the top layer.

An alternative method is by sulphonation. Evans describes the following method for toluene. A measured quantity (about 50 c.c.) of toluene is added to 150 c.c. of 98 per cent. sulphuric acid in a 250 c.c. graduated cylinder. The cylinder is carefully shaken, so that the temperature does not exceed 45° and the stopper is lifted frequently to avoid excess pressure. The cylinder is allowed to stand for five minutes and vigorously shaken for three to four minutes. The liquid is transferred to a separating funnel, the neck of which is narrow and graduated in 1/100 c.c. The bottom outlet of the funnel is connected by a rubber tube with a mercury reservoir. By this means the acid can be raised until the paraffin layer is contained in the narrow neck. The volume is read after two to three hours. A correction for solubility of 0·6 of the percentage of paraffins found is allowed.

Thiophene is detected by shaking in the cold with a sulphuric acid solution of isatin. This gives a blue coloration in presence of thiophene. This may be used as a colorimetric method for the estimation of thiophene.

Naphthalene is also used for the manufacture of nitro-derivatives. It should be in the form of pure white crystals of melting point 79° or over. It should not become yellow on exposure to air and light. It should give no residue on sublimation. A solution in concentrated sulphuric acid should give only a faint red colour. On boiling with water it should give no acidity. It should dissolve completely in benzene to a colourless clear solution. Naphthalene forms a sparingly soluble picric acid compound, which can be made use of in its estimation.

(b) Phenol

C_6H_5OH. Mol. wt., 94; sp. gr., 1·066 (15°); M.P., 41°; B.P., 181·5°; soluble in 100 parts water at 15°, 10·3; completely miscible at 84°.

Pure phenol forms colourless crystals; the commercial product has as a rule a slight reddish colour. A setting point of 40° is usually specified; a lower setting point indicates the presence either of water or of cresols. It should give a clear solution in 10 per cent. sodium hydroxide solution.

Phenol is used for the manufacture of picric acid. Metacresol can be similarly converted to trinitrometacresol. Technical metacresol contains ortho- and paracresol. On nitration these isomers are oxidised to oxalic acid. An approximate estimate of the content of metacresol can be obtained by a trial nitration under definite conditions. The pure metacresol gives 174 per cent. by weight of trinitro-compound, and the yield is proportional to the meta-content in mixtures of the isomers.

(c) Dimethylaniline

$C_6H_5N(CH_3)_2$. Mol. wt., 121·0; sp. gr., 0·955; M.P., 2°; B.P., 193°; slightly soluble in water; soluble in organic solvents.

Dimethylaniline serves for the preparation of tetryl (trinitrophenyl methylnitramine). It may contain water, aniline and monomethylaniline. It should be light in colour, free from mineral matter, and should give a clear solution when mixed with an equal volume of concentrated hydrochloric acid.

The presence of aniline is shown by the carbylamine reaction. Aniline and monomethylaniline react with acetic anhydride. An approximate estimate can be obtained by the rise of temperature when 50 c.c. of the dimethylaniline and 10 c.c. of acetic anhydride are brought together in a Dewar vessel. A comparative experiment should be made with dimethylaniline containing a known amount of monomethylaniline. Alternatively the amount of acetic anhydride used up may be determined by filtration. A weighed quantity of acetic anhydride (about 2·5 g.) is added to a weighed quantity of dimethylaniline (about 10 g.). The acetylation is allowed to proceed for two to three hours, 70 c.c. of water added and the whole warmed on a water-bath for half an hour and then titrated with sodium hydroxide. This gives the quantity of acetic anhydride not used in acetylation.

X. SOLVENTS

(a) Acetone

CH_3COCH_3. Mol. wt., 58·0; sp. gr., 0·7912 (20°/4°); B.P., 56·1°; soluble in water and organic solvents. For acetone and water density tables see Reilly and Ralph.[1]

Acetone should be colourless and completely miscible with water. Its specific gravity should not exceed 0·800 at 15°. It should give no turbidity on mixing with twenty times its volume of carbon disulphide, and no residue on evaporation. It should be free from acidity, except for traces of dissolved carbon dioxide (approximately 0·01 per cent.). To test acidity the acetone is boiled to remove carbon dioxide, diluted with an equal volume of water (free from carbon dioxide) and titrated with alkali, using phenol phthalein as indicator. Alkalinity should be absent, as it indicates the presence of amines; it is tested for by diluting and adding methyl red or para-nitrophenol.

Alcoholic impurities are detected by means of a reagent made up by dissolving 0·5 g. of potassium dichromate in 100 c.c. of nitric acid (sp. gr. 1·332). One c.c. of the acetone is mixed with 3 c.c. of the reagent, and allowed to stand for five minutes. No blue or violet colour should be formed.

Aldehydes and similar reducing substances are tested for by the permanganate test. A solution of 1 g. potassium permanganate in a litre of water is made up and 1 c.c. of this is added to 100 c.c. of acetone. The colour should persist for at least thirty minutes at 15·5° in the dark. In Germany, a silver nitrate test is included to detect aldehydes: these can also be detected by Schiff's reagent (fuchsine-bisulphite). "Light oils" also reduce ammoniacal silver nitrate. They may be tested for as follows.

Method 1. 100 c.c. acetone and 200 c.c. water are mixed and rapidly distilled in a retort. The first 10 c.c. of distillate is collected in a graduated cylinder, 20 c.c. of water added, and the volume of any oil which separates on standing is measured.

Method 2. 10 c.c. of acetone is added to 100 c.c. of water at 15°. Two c.c. of a solution containing 12·69 g. iodine and 14·60 g. potassium iodide is added. After exactly one minute, 2 c.c. of *N*/10 thiosulphate is added and the excess of thiosulphate titrated with iodine. One c.c. of *N*/100 iodine solution is equivalent to approximately 0·02 per cent. of the impurity.

The acetone content is usually estimated by Messinger's method. Two g. of acetone is mixed with 500 c.c. water; 10 c.c. of the mixture is mixed with 25 c.c. *N*/1 alkali and 50 c.c. *N*/10 iodine added with shaking. The mixture is shaken frequently and after fifteen to twenty minutes 26 c.c. of *N*/1 sulphuric acid added. The iodine is titrated with thiosulphate. The acetone is converted to iodoform; six atoms of iodine correspond to one mol. of acetone.

A method depending upon the action of mercuric sulphate is also stated to give satisfactory results.

Acetone may be detected qualitatively either by the above reactions or by the following test: The liquid is diluted with water, 2 drops of 5 per cent. nitroprusside, 2 drops of 5 per cent. sodium hydroxide and 5 or 6 drops of acetic acid are added. Acetone gives a red colour changing to violet on warming.

(b) Ethyl Ether

$(C_2H_5)_2O$. Mol. wt., 74·0; sp. gr., 0·713/15°; B.P., 34°; partially soluble in water; miscible with most organic solvents.

The liquid should be clear and colourless. The specific gravity is usually prescribed (*e.g.* 0·722) at 15°. The boiling point should be between 34° and 36°. The residue on evaporation should not exceed 0·002 per cent. On shaking with water, the aqueous extract should not be acid to litmus. In some specifications the acid is limited to 0·006 per cent. (as CH_3COOH).

Water may be tested for by anhydrous copper sulphate or by aluminium ethylate. Alcohol may be detected by the iodoform reaction, but acetaldehyde also gives this reaction. Acetaldehyde gives a greyish precipitate of mercury with Nessler's reagent. In Germany, a test which is used for acetaldehyde and vinyl alcohol is to add 5 g. solid potassium hydroxide to 30 c.c. of ether and allow to stand in the dark with shaking. After an hour there should be no separation of yellow or brown solid.

Hydrogen peroxide and organic peroxides may be detected by potassium iodide. Middleton gives the following method: 130 c.c. of 2·5 per cent. sulphuric acid is boiled, carbon dioxide being bubbled through the liquid. Five g. of ferrous sulphate is dissolved in it, and after cooling to 40°, 30 c.c. of a 10 per cent. solution of potassium thiocyanate added, and then, drop by drop, a *N*/300 solution of titanous chloride until the brown colour disappears. Five c.c. of this reagent is put into a 35 c.c. flask which is then filled with ether to the neck and allowed to stand for five minutes with occasional shaking. Peroxides are indicated by a brown colour, and may be determined by titration with *N*/300 titanous chloride.

Sulphur compounds are tested for by shaking with mercury. One drop of mercury should give no discoloration when shaken in presence of air with 10 c.c. of ether which has been acidified with a few drops of acetic acid.

(c) Ethyl Alcohol

C_2H_5OH. Mol. wt., 46·0; sp. gr., 0·789 at 20°; B.P., 78·3°; miscible with water and with most organic solvents with which it forms azeotropic mixtures.

The liquid should be clear and should give no turbidity with water. It should give no smell of fusel oil, and practically no residue on evaporation (0·01 per cent.). It should be as free as possible from acidity.

Fusel oil may be detected by adding water, shaking out with chloroform, separating, and allowing the chloroform to evaporate. The residue with addition of dilute sulphuric acid should give no smell of fusel oil. Fusel oil may be estimated quantitatively by oxidation to valeric acid.

Acetaldehyde and other aldehydes are tested for by ammoniacal silver nitrate; this should not become coloured or turbid on standing for a short time. Nessler's reagent should give only a slight precipitate.

Schiff's reagent may also be used. Siebert recommends a method in which the aldehyde is converted to aldoxime by hydroxylamine hydrochloride. Acid is liberated in the reaction, and is titrated with sodium hydroxide.

Acetone gives a red colour with sodium nitroprusside and alkali: aldehyde reacts similarly. More distinctive is the vanillin reaction ; 2 c.c. of a solution of 15 g. vanillin in 100 c.c. alcohol is mixed with 3 c.c. of the liquid under test and 1 c.c. conc. sulphuric acid. Acetone gives a carmine red colour, which turns yellow on addition of water. Alkali turns the colour bright orange red.

Methyl alcohol may be detected and estimated by conversion to methylaniline by means of iodine, phosphorus and aniline, followed by oxidation by stannic chloride to methyl violet. Other methods depend upon the conversion of the methyl alcohol to formaldehyde, which gives various colour reactions, *e.g.* with morphine sulphate and with fuchsine bisulphite.

Benzene may be separated by shaking with a concentrated solution of calcium chloride. For small quantities the alcohol is diluted with water, a small proportion is distilled over and the distillate shaken with potassium dichromate and hydrochloric acid. After fifteen minutes the solution is shaken with petroleum ether and the increase in volume of the petroleum ether layer is measured.

Ethyl alcohol may be identified in mixtures by conversion to ethyl benzoate or ethyl-*p*-nitrobenzoate by the Schotten-Baumann reaction.

B. ANALYSIS OF EXPLOSIVES

I. BLACK POWDER

Black powder consists of a mixture of nitre, charcoal and sulphur. The proportions vary somewhat, the nitre being generally about 74 to 78 per cent., the charcoal 12 to 16 per cent., and the sulphur 9 to 12 per cent. Allied mixtures are met with containing sodium nitrate in place of potassium nitrate, coal or soot in place of charcoal and occasionally other ingredients, such as resin, pitch, cellulose, etc.

(a) General Examination

The powder should show no differences in colour even when pulverised between the fingers. The grains should be hard, and on grinding the powder should break first into sharp-edged fragments. When poured over a sheet of white paper it should not leave traces of black dust. The size of grain is measured by sieving. The apparent density is found by pouring the powder into a measuring vessel, striking off the excess with a straight-edge, and weighing.

The "absolute" density is measured by displacement of mercury. An apparatus for this purpose was devised by Bianchi. In this method the air is removed from the interstices by evacuation. In the method used by the U.S.A. Bureau of Mines a vacuum pump is not required. These methods give figures of 1·65 to 1·85. This is not, however, the true absolute value, as the mercury does not penetrate into the finer interstices.

Gun-powder tends to absorb moisture in a damp atmosphere. The hygroscopicity may be determined by placing a weighed quantity on a small tray with a bottom of fine wire gauze enclosed in a box containing a saturated solution of potassium nitrate. The powder is left in the box for one to two days, according to the size of the grains, and is then weighed. Alternatively the gun-powder may be placed in a saturated atmosphere in comparison with a standard sample.

After storage in a damp atmosphere efflorescence of potassium nitrate crystals may occur. This can be detected under the microscope. Except for such efflorescence there is no tendency for the ingredients to segregate. If stored in contact with metals some reduction of the nitrate to nitrite may occur.

(b) Chemical Examination

Moisture. As sulphur is slightly volatile at 100° the moisture is estimated by heating at 70° for one and a half to three hours, or by drying in a desiccator over sulphuric acid for three days. Limits range from about 0·8 to 1·2 per cent.

Acidity. When the powder is extracted with water, the solution should not be more than very faintly acid to litmus paper.

Potassium Nitrate. Ten g. of the powder is extracted with warm water in a Gooch crucible, about 200 c.c. of water being added in quantities of 15 to 20 c.c. at a time. The final washings should give

no residue on evaporation. The diphenylamine test may also be used to see if the extraction is complete. The loss of weight of the crucible and contents, after drying at 70°, gives the percentage of potassium nitrate after allowing for the moisture content. As the charcoal contains a little water-soluble matter, it is necessary, for accurate determinations, to evaporate an aliquot portion of the filtrate and to heat it to incipient fusion. An estimate of the nitrate by means of the nitrometer is occasionally included.

The nitrate may be tested for chloride, sulphate, perchlorate, etc. (see Potassium Nitrate, p. 1).

The dried material in the crucible is extracted with carbon disulphide which has been recently distilled, until the washings give no residue of sulphur. The residue is dried in a warm place (avoiding flames) and finally at 100°. The loss of weight gives the sulphur.

In Gay-Lussac's method, 5 g. of the fine powder is mixed with 5 g. dry sodium carbonate. Five g. pure potassium nitrate and 30 g. sodium chlorate are added and the whole well mixed in a mortar, and ignited in a platinum crucible. After cooling, the mixture is dissolved in water, oxidised with bromine solution, acidified, and the sulphate estimated as barium sulphate.

Another method is to oxidise the original powder with 11 parts of pure conc. nitric acid and 2 parts of potassium chlorate until the liquid is clear and yellowish. The nitric acid is evaporated and the sulphur determined as sulphate. Petersen boils the powder with sodium hydroxide and hydrogen peroxide, and estimates as sulphate. Oehman gives a method in which the water-insoluble material is burnt in a bomb calorimeter.

Charcoal. This forms the residue after extraction of the potassium nitrate and sulphur. It should be examined for ash and total carbon content. It is also examined microscopically for wood meal, soot, etc.

It is sometimes preferred to proceed as follows: after the moisture estimation, a separate sample of 2·5 g. of the powder is extracted with carbon disulphide and the insoluble part weighed. From this the sulphur is calculated. For the nitrate, 2·5 g. is shaken with 250 c.c. of water and left overnight. An aliquot part is then evaporated to dryness and weighed. If desired, the nitrate may be converted to sulphate by adding sulphuric acid, drying and igniting; this removes organic matter. The charcoal is determined by difference.

II. NITRIC ESTERS

(a) Nitrocellulose

Nitrocellulose, as prepared from cellulose by nitric and sulphuric acids, consists of small fibres similar to the original cellulose. A microscopic examination gives an indication of the nature of the cellulose used for nitration. The length of fibre shows whether the pulping has been efficient. Apart from its rapidity of burning nitrocellulose may be distinguished from cellulose by acetone or ethyl acetate. These solvents gelatinise nitrocellulose, but do not affect cellulose. It may also be tested for nitrogen by diphenylamine and sulphuric acid. Some information as to the degree of nitration may be obtained by examination under polarised light.

Ungelatinised nitrocellulose will usually be received in the wet condition. The moisture can be determined, if required, by mixing the sample thoroughly, rubbing through a metal sieve, weighing out about 10 g. rapidly, and drying in a steam oven. Sometimes a lower temperature (50°) or evacuation over sulphuric acid is prescribed. If the stability of the dried nitrocellulose is to be determined, calcium chloride should be used as drying agent.

For the chemical tests, the sample is prepared by squeezing out the moisture as far as possible between layers of pure filter paper, teasing out loosely, drying at 50° and transferring to a desiccator.

Mineral Matter. About 3 g. of the nitrocellulose is weighed into a tared silica dish, covered with a layer of molten paraffin wax, stirred and ignited, care being taken to avoid loss. After all has burnt off, the contents of the dish are moistened with ammonium carbonate, dried and treated to 105-110°. Sometimes sulphuric acid is used for moistening, and the residue ignited. Another method is to moisten the nitrocellulose with nitric acid and heat on the water-bath. The residue is then ignited. After cooling, a little water is added, evaporated, and the residue again ignited.

Calcium Carbonate. Ten g. of nitrocellulose, 100 c.c. of $N/10$ hydrochloric acid and 100 c.c. water are put into a stoppered cylinder, shaken for an hour, and the excess of acid titrated with $N/10$ sodium carbonate, using methyl orange as indicator.

Soluble Salts. Nitrates are sometimes mixed with nitrocellulose and may be determined by extraction with water.

Paraffin Wax. A coating of wax is sometimes present; this can be extracted with ether.

Stability Tests. The tests are described in Section C (p. 70 *et seq.*). The Heat test, Bergmann and Junk test, and Will test are frequently applied. A limit of 10 mins. at 170° F. is laid down by the Home Office for the Heat test.

Nitrogen. Numerous methods have been applied to this determination. They include gravimetric methods (nitron), volumetric methods depending on reduction of the nitric acid to ammonia, and gas volumetric methods. The methods most commonly used are the nitrometer method (Lunge) and modifications of the Schulze-Tiemann method, depending on the action of ferrous chloride.

Nitrometer method.

The nitrocellulose is passed through a sieve and dried. About 0·6 g. is weighed into a small weighing bottle. To ensure complete drying the bottle and contents may be dried for an hour in a steam oven and weighed. Concentrated sulphuric acid (6 to 8 c.c.) is added and allowed to stand for twenty to thirty minutes to dissolve the nitrocellulose. The solution is washed with small quantities of sulphuric acid into the cup of the nitrometer and allowed to flow into the bulb. This should be done without delay. About 0·5 c.c. water is added to the last portion of sulphuric acid. The nitrometer is shaken and the nitric oxide is measured in the usual way. The shaking should not be too prolonged, as this decreases the gas volume. The nitric oxide contains traces of other gases (carbon monoxide, etc.) which tend to increase the gas volume; on the other hand a little nitric oxide is absorbed by the sulphuric acid. The solubility is at a minimum in 85 per cent. sulphuric acid. Webb and Taylor recommend the use of 91 to 92 per cent. sulphuric acid, and allow 0·2 c.c. in 10 c.c. acid for the solubility.

In the Du Pont nitrometer direct readings of the nitrogen percentage can be made without the necessity of correcting the volume of gas to standard temperature and pressure. The apparatus consists of (1) a generating bulb with mercury reservoir attached, as in Lunge's nitrometer, and (2) a reading apparatus, with a closed compensator bulb containing dry air. The generating bulb has a two-way stopcock, connecting either with the cup or with an exit tube. The sample is introduced and shaken with mercury and sulphuric acid. The quantity must be such that the gas volume is between 171·8 and 240·4 c.c. The nitric oxide is transferred to a reading burette, which is connected at its lower end by rubber tubing to (1) a mercury reservoir and (2) a closed compensator bulb with a lower tube which is marked with a graduation mark. The levels are adjusted so that the mercury is at the level of the graduation mark on the compensator tube, and is at the same time balanced between this and the reading burette. The reading is then taken. The reading burette is calibrated from 10 to 14 per cent. of nitrogen for 1 g. of substance. The instrument is standardised by carrying out a measurement with pure potassium nitrate.

The Schulze-Tiemann method depends upon the action of boiling ferrous chloride solution in presence of hydrochloric acid. This converts the nitrogen of the nitrocellulose to nitric oxide.

The apparatus used in Reinhold's method is shown in Fig. 1. The vessel in which the gas is evolved consists of a round-bottomed flask of 300 c.c. capacity made of Jena glass with a long neck. The stopper is of glass and is connected with two glass tubes as shown. The connection between stopper and flask is made by means of a short length of rubber tube which is fitted between the two and makes a gas-tight joint.

The tube A is connected by a rubber tube with a glass tube about 12 cm. long, constricted at the end, and dipping into a small beaker of water. The tube B is connected by a rubber tube with a forked glass tube. One of the branches is connected to a drawn-out tube dipping into water. The other is joined by a short rubber tube to the measuring apparatus. Spring clips are affixed to the rubber joints as shown.

The flask is clamped over a bunsen burner with a small flame. The measuring apparatus consists of the measuring tube (M), the levelling tube (N), and a connecting tube (Z) of special construction, which enables the flask in which the gas is evolved to be connected with the measuring tube. The upper portion of the measuring tube is widened, and the calibrations commence at 100 c.c. at the place where the tube narrows, and extend to 130 or 150 c.c. The tube is jacketed as shown, to permit of cooling by water. The levelling tube is of the same internal diameter as the measuring tube, and is also jacketed. The tube with pinch-cock at the bottom serves to draw off the liquid as required. The liquid consists of 30 per cent. potassium hydroxide. The measuring tube and levelling tube are filled and the tube leading to the flask is filled as far as the junction of the two tubes.

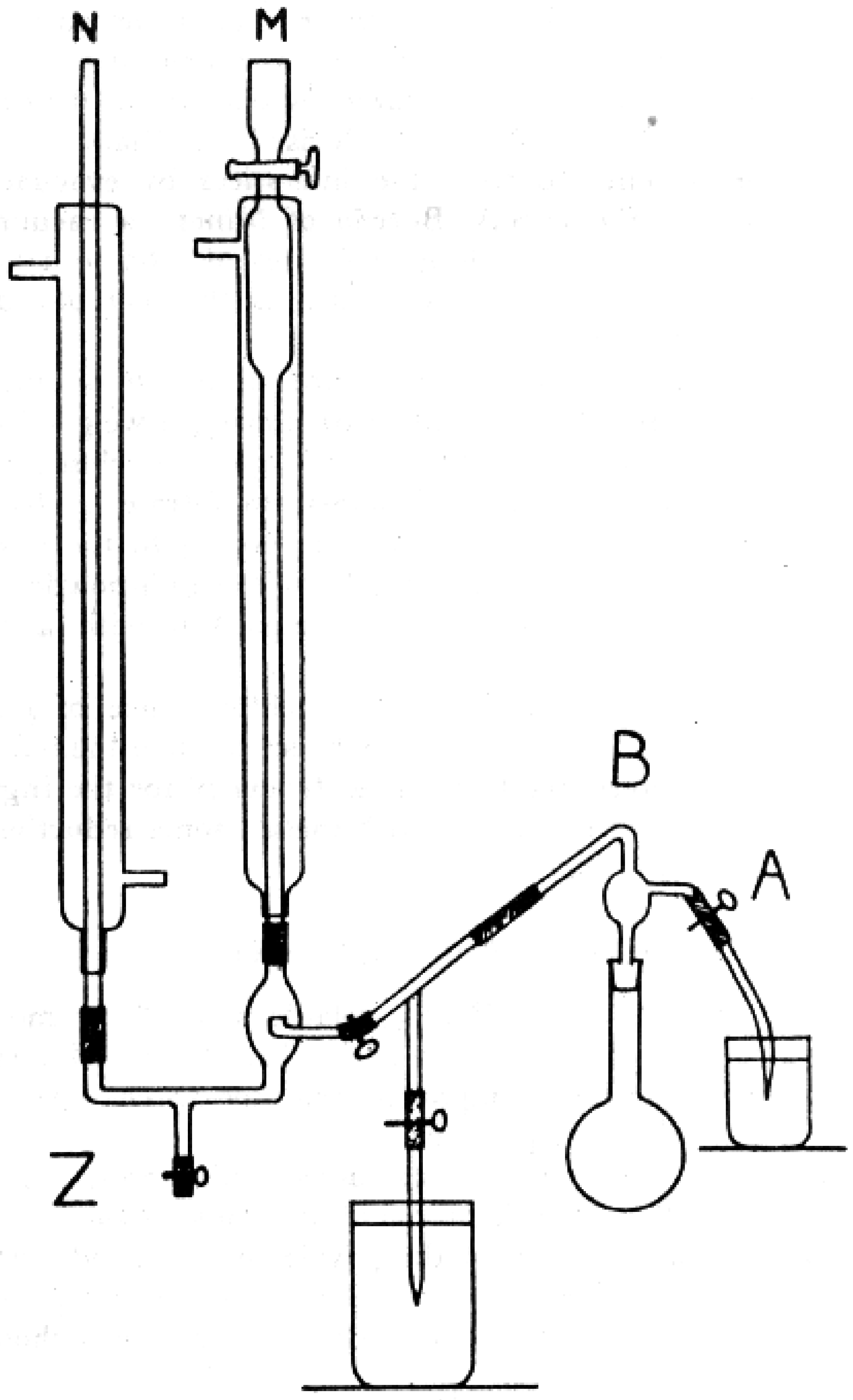

Fig. 1.

The nitrocellulose is dried and 0·6 g. weighed into the flask, 30 c.c. of water being then added. The apparatus is connected up as shown. The flask is heated over a free flame, the clips remaining open. When all the air has been expelled, both clips are closed and the flame is simultaneously removed; 25 c.c. of concentrated ferrous chloride is put into the smaller beaker and sucked into the flask by opening the clip cautiously to avoid influx of air. Thereupon 20 c.c. conc. hydrochloric acid is introduced in the same way, and finally a small quantity of water. The flask is then heated carefully until the rubber connections show signs of a positive pressure, and on cautious opening of the pinch-cock no more liquid enters the flask. The pinch-cock connecting the flask with the measuring tube is opened, and the nitric oxide is driven over, the contents of the flask being vigorously boiled. At the same time the cooling water is set in action, and a thermometer suspended in the cooling-jacket. When no more gas passes over, the pinch-cock is closed, the flame is removed, and the flask allowed to cool somewhat. This sets free the dissolved nitric oxide, and the flask is again heated to drive over the remaining nitric oxide. When the gas evolution comes to an end, the pinch-cock is closed, and the flame is turned out, and the alkaline liquid is drawn off from the cock at the bottom of the measuring tube and levelling tube, until the liquids are at the same level in both tubes. The volume of gas can be read off at once. The temperature and barometric pressure are also read. The two tubes should be at approximately the same temperature. The nitrogen content is readily calculated from the volume of nitric oxide.

The ferrous chloride solution is made by warming conc. hydrochloric acid with excess of iron nails, filtering, and adding a little conc. hydrochloric acid. It should be moderately fresh. All solutions must be free from dissolved air.

The Schulze-Tiemann method is generally found to give somewhat low results, compared with the nitrometer.

For the determination by the nitron method 0·2 of nitrocellulose is brought into a 150 c.c. Erlenmeyer flask with 5 c.c. of 30 per cent. sodium hydroxide solution and 10 c.c. of 3 per cent. hydrogen peroxide, warmed for a few minutes on the water-bath until frothing ceases, and then boiled on a free flame. The nitrocellulose should pass into solution in a few minutes. After cooling, 40 c.c. of water and 10 c.c. of hydrogen peroxide solution are added, the solution warmed to 50° and 40 c.c. of 5 per cent. sulphuric acid allowed to flow into the bottom of the flask by a pipette. The solution is further warmed to 80° and 12 c.c. of nitron acetate added (10 per cent. solution of nitron in 5 per cent. acetic acid). After cooling and standing for one and a half to two hours (preferably at 0°) the nitron nitrate is filtered off and washed three or four times with 10 c.c. of ice-cold water. The precipitate is dried at 110°. From the weight of the $C_{20}H_{16}N_4HNO_3$ (mol. wt. 375) the nitrogen content of the nitrocellulose is calculated.

Unnitrated Cellulose. Five g. of nitrocellulose is boiled for half an hour with a saturated solution of sodium sulphide, allowed to stand for twenty-four hours, the solution decanted, and the residue boiled again with fresh sodium sulphide. The insoluble matter is collected on a linen filter of known weight, washed with hot distilled water until free from sulphide, then with dilute hydrochloric acid and finally with water until free from chloride. The residue is dried at 50° and weighed. It is then ignited in a platinum crucible and the weight of the ash deducted from that of the total residue.

According to Lunge and Weintraub the sodium sulphide method is inaccurate, as the residue contains nitrocellulose. They therefore worked out a method in which the nitrocellulose is treated with sodium ethylate and acetone.

Another method is to boil 5 g. nitrocellulose for forty minutes with 30 c.c. of a solution of stannous chloride in excess of sodium hydroxide, allow to stand for twenty-four hours, decant carefully, boil the residue again with 30 c.c. of the solution, filter, wash with water, then with 5 per cent. hydrochloric acid and again with water, dry and weigh. Then ignite and deduct the weight of the ash.

The unnitrated cellulose may also be determined by dissolving the nitrocellulose in acetone. Five g. of nitrocellulose is treated with a litre of acetone and allowed to stand for twenty-four hours with frequent shaking. The solution is decanted, the residue filtered, washed with acetone, dried at about 70°, and weighed.

Solubility in Ether-Alcohol. The lower nitrates of cellulose are in general more readily soluble in a mixture of ether and alcohol than the higher nitrates. The general method of testing is to introduce a weighed quantity of nitrocellulose into a measuring cylinder and shake with a mixture of ether and alcohol. The temperature at which this is done is of importance; sometimes 15·5° is specified, and sometimes 20°. After shaking at frequent intervals for six hours, the cylinder is allowed to stand overnight to allow the insoluble nitrocellulose to settle, and an aliquot portion of the clear liquid is withdrawn and evaporated. Usually the bulk of the liquid is distilled off in a flask on a water-bath, and the remainder is washed into a glass dish with ether-alcohol and evaporated to dryness. It is advisable to add a little water before or during the evaporation, as this causes the nitrocellulose to separate out in a looser condition in which it can be more readily dried. The temperature is finally raised to 80° and the dish is then cooled in a desiccator and weighed.

The quantity of nitrocellulose and the proportions of ether and alcohol vary somewhat, *e.g.* 2 to 4 g. may be treated with 150 c.c. of ether-alcohol (2 : 1). In Germany the proportion of ether to alcohol is 4 : 3, 2 g. of nitrocellulose being shaken with 215 c.c. alcohol and 285 c.c. ether. In some cases it is preferred to shake first with alcohol and then add the required quantity of ether, as this avoids the formation of gelatinous lumps.

The above method is in general use for gun-cotton, which is mainly insoluble in ether-alcohol. It may also be used for nitrocelluloses which are almost completely soluble, but alternative methods have been devised for the latter in which the insoluble portion is estimated. Thus, after treatment with ether-alcohol and settling, the clear liquid may be siphoned off and the residue again treated with ether-alcohol, the treatment being repeated as required. The residual suspension is ultimately filtered through a filtering tube fitted with a plug of asbestos, and the insoluble matter dried and weighed. A shortened method is also described in which the liquid, after standing, is transferred to a tube which is tapered at the bottom to a narrow graduated portion. An approximate estimate of the insoluble nitrocellulose may be obtained from the volume which it occupies in the narrow part of the tube.

Sulphates. These include sulphuric esters together with any inorganic sulphate ($CaSO_4$). Dunnicliff gives the following method: 5 g. of nitrocellulose is heated on a water-bath with 50 c.c. conc. nitric acid until the nitrocellulose has dissolved and brown fumes have ceased. About 1 g. sodium chlorate is added in small quantities and the whole evaporated to dryness. The residue is treated with 20 c.c. of hydrochloric acid and 0·5 sodium chlorate (added in small quantities) and the liquid again evaporated to dryness. This latter treatment is repeated. This converts all sulphuric esters to soluble sulphate, which may be estimated in the usual way. A blank test is made to allow for sulphate in the reagents.

An alternative method is to destroy the nitrocellulose by boiling with nitric acid containing potassium nitrate, heat the residue strongly, dissolve in hydrochloric acid, filter, and determine the sulphate.

Mercury. Traces of mercury mask the heat test, and it is important to ensure its absence. Probably the most sensitive method for the detection of mercury is to examine the spectrum given by an electrical discharge through a vacuum tube containing the material under test, the latter being kept at a temperature of 100°. Alternatively the explosive under test may be heated in a vessel in which gold leaf is placed, and the gold leaf subsequently tested in the vacuum tube. In the latter method the presence of mercury is also shown by whitish-grey spots of amalgam on the gold.

Viscosity. The nitrocellulose is dissolved in ether-alcohol or acetone and the viscosity determined in a viscometer. It is usual to find the time required by a steel ball to drop through a measured height of the solution.

For the detection of nitrocellulose in explosives, Stansky recommends extracting with acetone, evaporating the solution to a small bulk and adding chloroform to precipitate the nitrocellulose. This is then hydrolysed with sodium hydroxide solution, and tested for nitrate by diphenylamine and sulphuric acid.

(b) Nitroglycerine

Glyceryl trinitrate, $C_3H_5(NO_3)_3$. Mol. wt., 227·0; sp. gr., 1·600; M.P., 13°; soluble in 100 parts water, 0·14 at 15°, 0·35 at 90°; soluble in organic solvents.

Nitroglycerine seldom comes into commerce as such. The examination of nitroglycerine is therefore as a rule necessary only in works laboratories. If it is in solution in alcohol or acetone, it should be separated by dilution with water and filtered through dry salt.

Nitroglycerine should form a clear, or very slightly turbid, pale yellow liquid. The moisture is estimated by allowing to stand over calcium chloride (not sulphuric acid) in the cold. Nitroglycerine should be practically free from acidity and alkalinity; to test for these, 20 g. is shaken with 50 c.c. of water and the water tested with litmus and if necessary titrated, using methyl orange as indicator.

The nitrogen content is usually determined by the nitrometer method. Another method is to saponify the nitroglycerine with sodium ethylate and reduce to ammonia with a mixture of powdered zinc and iron.

Stability tests are given under C (p. 70 *et seq.*).

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The limit for the heat test of nitroglycerine extracted from dynamite, etc., is fifteen minutes at 160° F. The nitroglycerine must be dry, as moisture prolongs the test. It should be filtered into the test tube through a dry filter paper, taking care that it does not wet the sides of the tube.

It has been found by Crawford that small quantities of tetranitromethane and nitrochloromethanes are frequently present in nitroglycerine, and depress the heat test. They may be removed by shaking with sodium sulphite solution.

The melting point is occasionally used as a criterion of the purity of nitroglycerine. Nitroglycerine supercools very readily and must be seeded with crystals of the solid substance.

Mixtures of nitroglycerine with tetranitrodiglycerine are tested in general similarly to nitroglycerine. An admixture of 30 per cent. tetranitrodiglycerine lowers the nitrogen percentage to 17·6-17·7. The physical properties of the mixture are not sharply defined; it is a viscous oil of indeterminate freezing point. In its solubilities, etc., it is in general similar to nitroglycerine.

(c) Dinitroglycol

Ethylene glycol dinitrate, $C_2H_4(NO_3)_2$. Mol. wt., 152·0; sp. gr., 1·496 (15°); M.P., −20°; soluble in 100 parts water, 0·6 at 15°; soluble in organic solvents.

Dinitroglycol is a colourless liquid, less viscous than nitroglycerine. It has a very low freezing point and in admixture with nitroglycerine the freezing point is still further depressed. It is a frequent constituent of non-freezing explosives. It dissolves in most organic solvents, but is sparingly soluble in carbon disulphide.

Dinitroglycol is tested similarly to nitroglycerine. It is, however, considerably more volatile than nitroglycerine and loses weight readily on heating, and even to some extent at ordinary temperature. It should give no residue on evaporating at 50° (absence of nitroglycerine, etc.).

The nitrogen content is almost identical with that of nitroglycerine and does not therefore give any indication of the percentage composition of mixtures.

Marqueyrol and Goutal have given methods for the estimation of dinitroglycol in nitroglycerine. These depend on the action of sulphuric acid and the depression of the freezing point of benzene.

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(d) Dinitrochlorhydrin

Chlorohydrin dinitrate, $CH_2ClCH(NO_3)CH_2NO_3$. Mol. wt., 200·5; M.P., α: +5°, β: +16°; sp. gr., 1·541 at 15°; solubility in 100 parts water, 0·23 at 15°; soluble in organic solvents.

Dinitrochlorhydrin forms a colourless liquid with a slightly aromatic odour. The commercial product is yellow to yellowish-brown. It is less viscous and more volatile than nitroglycerine.

Dinitrochlorhydrin always contains a small proportion of nitrodichlorhydrin. A chlorine estimation of a mixture in which nitroglycerine is also present does not therefore give definite evidence of the composition. The nitrogen determination also cannot be relied upon, unless the unchlorinated portion of the raw material is known.

The examination includes determination of specific gravity, nitrogen and chlorine content. The nitrogen content of the pure dinitrochlorhydrin is 13·97 per cent. In practice about 13·80 to 13·85 per cent. is found. The chlorine is estimated by saponification with alcoholic potassium hydroxide (15 per cent.). After boiling for fifteen minutes the liquid is evaporated and the residue heated, then dissolved in water, neutralised with nitric acid, the nitrite oxidised with permanganate, and the chlorine estimated.

In some cases the refractive index is made use of for mixtures, but the results are not usually very reliable.

(e) Starch Nitrate

Nitrated starch is used in the United States as an ingredient of blasting explosives. The nitration of starch gives nitric esters with about the same nitrogen content as with celluloses. The starch nitrate (often incorrectly designated *nitro*-starch) dissolves readily in acetone and ethyl acetate and to some extent in ether-alcohol. The solutions show a relatively low viscosity. It is much more hygroscopic than cellulose nitrate and is mixed with oils to prevent absorption of water. A partly acetylated starch on nitration gives a less hygroscopic product due to reduction of free hydroxyl groups in the nitrated product.

The nitrogen content is determined by the nitrometer method, Difficulty is experienced, as the starch nitrate does not dissolve very readily in the sulphuric acid. It may, however, be dissolved by shaking in a stoppered bottle and then introduced into the nitrometer.

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Carbonates are estimated as in cellulose nitrate. Stability tests are also included. In America the loss of weight at 100° is measured (see Section C, VI. (*a*), Sy's method, p. 85). The stability is somewhat poor.

(f) Nitromannite

Mannite hexanitrate, $NO_3 . CH_2(CHNO_3)_4CH_2NO_3$. Mol. wt., 452; sp. gr., 1·604; M.P., 112° to 113°; insol. water, slightly sol. cold alcohol, sol. ether and acetone.

This forms a somewhat voluminous white crystalline powder, which should give a clear solution in ether. The pure compound contains 18·58 per cent. of nitrogen and the technical product approaches this value. The stability is somewhat poor and the explosive is expensive. The purity of the compound is best determined by the melting point.

(g) Nitrated Polysaccharides

Recently, in addition to nitrated celluloses, starch nitrate, etc., various nitrated products of other polysaccharides have received attention, *e.g.* nitrated inulin, nitrated lichenin. The following is an example of the preparation of one of these products on a small scale :

Finely powdered lichenin (1 part) was gradually added at room temperature to a mixture (50 parts) of 3 parts by weight of sulphuric acid (sp. gr. 1·84) and 1 part by weight of nitric acid (sp. gr. 1·5). After each addition of lichenin, the nitration mixture was stirred. The lichenin nitrate was separated by decantation, and purified by boiling for a short time first with slightly acid water, then with alkaline tap water, finally with distilled water, and then dried at low temperature. $C_{12}H_{15}O_5(NO_3)_5$ requires $N = 12·7$ per cent.

Lichenin pentanitrate is readily soluble in acetone, ethyl acetate, and amyl acetate, but insoluble in ether, benzene, and water. When gelatinised with a solvent, it gives a product resembling horn. Like nitrocellulose of the same percentage nitrogen composition, it is almost completely soluble in a mixture of ether and alcohol, and decomposes at high temperatures, giving off oxides of nitrogen.

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(h) Tetranitropentaerythritol (Penthrit)

Pentaerythritol-tetranitrate, $C(CH_2NO_3)_4$. Mol. wt., 316·0; sp. gr., 1·73 to 1·74; M.P., 140° to 141°; insol. water, slightly sol. in ether, sol. acetone.

Pentaerythritol-tetranitrate should be in the form of fine white crystals and should have no tendency to agglomerate. The technical product melts at 135° to 137°. The pure compound (M.P. 138·5° to 141°) gives a clear solution in warm acetone, but a slight residue of calcium salts is usually found. The compound should be neutral. The nitrogen content of the pure compound is 17·74 per cent.; usually a percentage of 17·3 to 17·4 is found. Other tests include ash, moisture and acidity. The last is determined by dissolving in acetone, reprecipitating with water, filtering and testing the filtrate for sulphuric and nitric acid.

III. Aromatic Nitro-compounds

A number of higher nitro-compounds of benzene derivatives are used for military purposes, *e.g.* trinitrotoluene and trinitrophenol. Mono- and dinitro-compounds are used in industrial explosives. The separation of mixtures of nitro-compounds is somewhat difficult; in some cases steam distillation is of assistance, a partial separation may be effected by solvents, and certain colour reactions are used. Several general tests for the nitro-group have been described. Olivier recommends dissolving in benzene and adding aluminium chloride; nitro-compounds give a red colour. Mulliken and Barker dissolve the nitro-compound in alcohol, add a trace of calcium chloride, reduce with zinc and test for the hydroxylamine group by the silver mirror test. In an alternative method, 3 to 4 drops of the compound are boiled with 2 c.c. of a mixture of equal parts of aniline and ortho- and para-toluidine together with 2 c.c. of water, 2 c.c. of conc. hydrochloric acid and a gram of iron filings. This gives fuchsine, which on pouring into dilute acetic acid gives a red colour. A number of the nitro-compounds give characteristic colours with alkalis and these are of assistance in the identification of the compounds.

For the quantitative estimation the nitrometer method is not in general applicable, though the nitramine group in tetryl responds to this test. The Dumas method may be used under precautions, and the Kjeldahl method is sometimes used for the lower nitro-compounds. Titration methods depending on reduction with stannous chloride are described by Limpricht, Reduction with titanous chloride and sulphate is also employed.

The tests which are applied to nitro-compounds usually include setting point, volatile matter, free acid, residues insoluble in organic solvents, and ash. Occasionally special tests for exudation, etc., are specified.

(a) Picric Acid

Trinitrophenol $(NO_2)_3C_6H_2OH$. Mol. wt., 229·0; sp. gr., 1·76; M.P., 121·6°; soluble in 100 parts water, 0·8 at 0°, 6·33 at 100°; soluble in organic solvents.

Picric acid should be of uniform yellow colour and free from visible impurities. It should melt to a yellow or light brown liquid, which should not darken on continued heating. The melt should be practically free from scum or deposit.

Metallic picrates and oxalates should be absent, and other nitro-compounds should be present only in traces. The melting point or setting point carried out on a well-dried sample should be at least 120°. The moisture content is generally limited to 0·1–0·25 per cent., and the ash to 0·05–0·1 per cent.; this should not be of a gritty nature. Impurities insoluble in water should not exceed the ash content by more than 0·05 per cent. The picric acid should be almost completely soluble in benzene. Sulphates are restricted to 0·05–0·1 per cent. (as SO_3). Chlorides and nitrates are sometimes tested for. Absence of lead in any form which might give rise to the formation of lead picrate is of special importance. Lead sulphate is, however, comparatively harmless.

The setting point is determined by allowing the molten acid to cool slowly in a broad air-jacketed test tube.

The volatile matter is measured by heating for two hours at 100°, or three hours at 80°, or in a vacuum desiccator over sulphuric acid for twenty-four hours.

For the determination of the ash, 10 g. of the picric acid is added in very small quantities to a heated crucible. The temperature is then raised to burn off carbon, and the residue is moistened with nitric acid, then with a little sulphuric acid, and again ignited. An alternative method is to moisten the picric acid with concentrated sulphuric acid and heat it gradually.

Sulphates are determined in the ordinary way. Large excess of barium chloride should be avoided.

For the detection of picrates, the picric acid is extracted with benzene, and the residue is examined under the microscope and tested by burning. The benzene residue is also examined for oxalates.

Nitrophenolsulphonic acids may be estimated by melting with excess of sodium carbonate, determining the sulphate formed and subtracting the sulphate originally present.

Picric acid may generally be detected by its intense yellow colour and dyeing properties, also by its bitter taste. It may be extracted from its aqueous solution by ether after acidifying strongly with sulphuric acid. On heating with potassium cyanide and sodium hydroxide to 60°–70°, picric acid gives a blood-red colour. Ammonium sulphide also gives a red colour with picric acid. Potassium ferrocyanide gives on warming a bright blue colour and ferricyanide a red colour, both of these changing to reddish-violet. Copper ammonium sulphate gives a greenish-yellow precipitate. Methylene blue gives a violet precipitate. Picric acid forms a sparingly soluble potassium salt, and gives characteristic compounds with naphthalene and phenanthrene. The picrates of cinchonine, berberine, acridine and nitron are almost insoluble and may be used for the quantitative estimation of picric acid. Picric acid may be titrated with alkali, using phenol phthalein or methyl red as indicator.

Ammonium picrate forms yellow crystals which dissolve readily in water. It should be practically free from insoluble matter (0·2 per cent.) and should not give more than 0·2 per cent. of ash.

Trinitrocresol resembles picric acid in general, but melts at 107° and gives a readily soluble potassium salt.

(b) Dinitrotoluene

$CH_3C_6H_3(NO_2)_2$. Mol. wt., 182; M.P., 70·5°; insol. water, soluble in organic solvents.

A large number of industrial explosives contain dinitrotoluene or trinitrotoluene or mixtures of these. The dinitrotoluene is mainly the 1 . 2 . 4 isomer, but contains some of the other isomers. Different grades of purity are met with; a good quality material has a setting point of 66° to 68°. It should not smell of mononitrotoluene. The acidity should not exceed 0·1 per cent. and the compound should melt to a transparent yellow liquid. The volatile matter should not exceed 0·25 per cent., and the residue on ignition should not be greater than 0·05 per cent. On dissolving in benzene, the residue should not exceed 0·10 per cent.

(c) Trinitrotoluene

$(NO_2)_3C_6H_2CH_3$. Mol. wt., 227·0; sp. gr., 1·68; M.P., 81°; soluble in 100 parts water, 0·02 at 15°, 0·16 at 100°; soluble in organic solvents.

Trinitrotoluene (also known as TNT, trotyl, trinol, etc.) is used as such and also in admixture with ammonium nitrate, etc., in explosives such as amatol, ammonal, sabulite, donarite, etc. This substance is the most important military high explosive.

The pure compound forms pale yellow crystals. The best indicator of the purity is the setting point. At the present time the commercial product is available in a very high degree of purity. The compound must be dry, as the setting point is depressed by water. About 50 g. of the trinitrotoluene is melted in a dish at 100°; any drops of water are removed by means of a filter paper, and the heating is continued for two hours with stirring. The molten material is poured into a broad test tube fitted with a cork and thermometer. This tube is fitted into a wider tube leaving an air space of about 5 mm., and the double tube is placed in a vessel of about 1 litre capacity. The trinitrotoluene is stirred during cooling, and the maximum temperature after crystallisation has set in is observed. For crude trinitrotoluene a setting point of about 76° is usually required, and for purified trinitrotoluene 80° or sometimes slightly higher. The molten trinitrotoluene should be of a medium brown colour and should not darken on continued heating at 100°. It should be clear and should not deposit any particles of grit.

A benzene solution of the trinitrotoluene should contain only traces of insoluble organic compounds (0·1 to 0·2 per cent.).

For the estimation of the ash, 5 g. of the substance is moistened with 2 c.c. sulphuric acid and burnt off. The residue is moistened with a little nitric acid, then with sulphuric acid and reheated. The ash should not exceed 0·05 per cent.

The volatile matter may be estimated by the "dish and cone" method (see Smokeless Powder, p. 50). It is also sometimes determined by drying on a watch glass in a vacuum at ordinary temperature. Limits of 0·1 to 0·25 per cent. are usually specified.

For the determination of acidity, the trinitrotoluene is melted under water with stirring. The water is decanted and the extraction repeated twice. The water extract is tested either with litmus or by titration to phenol phthalein. The acid may include sulphuric and nitric acid, which are sometimes tested for separately, and organic acids (nitrocresols, etc.).

Tetranitromethane in crude trinitrotoluene may be estimated by reduction of hydrazine in alkaline solution to nitrogen

"Liquid trinitrotoluene" is a mixture of isomeric trinitrotoluenes with some dinitrotoluene which forms a by-product in the purification of trinitrotoluene by crystallisation or centrifuging. It has a limited use in commercial explosives. Its melting point and other properties are very indefinite.

(d) Dinitrobenzene

$C_6H_4(NO_2)_2$. Mol. wt., 168; M.P., 90°; insol. water; soluble in organic solvents.

Dinitrobenzene is but little used. It is objectionable on account of its poisonous properties. The main ingredient is the meta-derivative, but the other isomers are also present, and the commercial product may give a setting point as low as 80°. It should be free from mononitrobenzene, which can be recognised by its smell.

(e) Trinitrobenzene

$C_6H_3(NO_2)_3$. Mol. wt., 213; M.P., 122°; insol. water; soluble in organic solvents.

Trinitrobenzene is also but little used. It forms additive compounds with amines and with naphthalene. It gives an intense red colour with alkalis in presence of alcohol.

(f) Nitronaphthalenes

These are used in various mixed explosives. They are usually met with in an impure form.

Mononitronaphthalene. The commercial product consists mainly of the alpha-compound. The pure compound melts at 61°. The commercial product should have a melting point of at least 56°. It boils at 304°. It is tested in the usual way for absence of acidity, insoluble matter, etc.

Dinitronaphthalene. This is a mixture of the 1.5-isomer (M.P. 217°) and the 1.8-isomer (M.P. 170°). It has an indefinite melting

point, usually about 135° to 140°. It forms a dirty yellow to red brown crystalline powder. It gives a pink colour with alcoholic ammonia.

Trinitronaphthalene. This was used to some extent during the war in admixture with picric acid, etc. It is a mixture of various isomers and has no definite melting point. The melting points of the individual constituents are 1 : 3 : 8 (218°), 1 : 2 : 5 (113°), 1 : 3 : 5 (122°), 1 : 4 : 5 (154°). Some dinitronaphthalene is also present. The nitrogen percentage gives some indication of the proportion of trinitro-compound.

(g) Tetryl

Trinitrophenyl methyl nitramine $(NO_2)_3C_6H_2N(CH_3)NO_2$. Mol. wt., 287; sp. gr., 1·725; M.P., 131°; insol. water; soluble in organic solvents.

Tetryl forms a yellow crystalline solid. It should melt at 129° or above. It decomposes somewhat readily when molten and the setting point cannot be satisfactorily measured. It should leave only a trace of residue when dissolved in acetone and should be practically free from acid. In some countries a distinction is drawn between surface acid and that which is found by dissolving the tetryl in an organic solvent and adding water. Tetryl is much less soluble in carbon tetrachloride than trinitrotoluene; this is made use of for the separation of the nitro-compounds. Melting-point diagrams are also made use of to estimate the composition of such mixtures.

The nitramine nitrogen may be estimated by the nitrometer method. Tetryl is less stable than the majority of nitro-compounds. The stability may be estimated by the evolution of gas on heating in a vacuum (see p. 92).

(h) Other Nitro-compounds

Dinitrophenol $(NO_2)_2C_6H_3OH$. The pure 1 : 2 : 4 compound melts at 114°, commercial samples usually at about 110° to 112°. It has acid properties and forms salts. It should dissolve completely in cold dilute sodium hydroxide solution and in benzene, and should not contain more than 0·1 per cent. of organic chlorine. It should be free from lead. It is somewhat volatile in steam and can be separated from picric acid by steam distillation, though not very readily. The dinitrophenol in a mixture with picric acid may be estimated by bromination.

Trinitroanisole $(NO_2)_3C_6H_2OCH_3$. This is the methyl ester of picric acid and as such can be hydrolysed to picric acid by warm

alkalis. The pure substance melts at 68°, the commercial product at about 65°. It should be free from mineral acids and from picrates.

Trinitroresorcinol (Styphnic acid) $(NO_2)_3C_6H(OH)_2$. This is an acid somewhat similar to picric acid in its general properties. It melts at 175·5°.

Trinitrochlorobenzene $(NO_2)_3C_6H_2Cl$. This has been very little used as an explosive, but serves for the preparation of other trinitro-compounds. It melts at 83°. The chlorine is very reactive and is readily replaced by the amino- or hydroxy-group.

Hexanitrodiphenylamine $(NO_2)_3C_6H_2.NHC_6H_2(NO_2)_3$. This compound melts at about 230°, but undergoes decomposition below the melting point. It is almost insoluble in most solvents, but dissolves in a mixture of acetone and pyridine, and the solution should leave very little insoluble residue. The compound has acid properties and forms salts of various metals.

2-4-6 *Trinitrometaxylene* $(CH_3)_2C_6H(NO_2)_3$. On nitration of commercial xylene, this product is obtained in admixture with *o*- and *p*-nitrated xylenes, especially dinitro-derivatives. The melting point of the crude explosive is 182°, and to lower the melting point the product is mixed with trotyl.

Hexanitrodiphenylsulphide $(NO_2)_3C_6H_2SC_6H_2(NO_2)_3$. The pure substance melts at 233°, the commercial product at about 225°. It is tested as usual for acids and other impurities.

Tetranitroaniline. Yellow crystals of M.P. 216°.

IV. SMOKELESS POWDERS

The composition of smokeless powders varies greatly, but they contain in general nitrocellulose, either completely or partially gelatinised. The completely gelatinised powders have a more or less horny structure; the partially gelatinised powders are porous, and can be comparatively easily broken down to powder. Many smokeless powders contain nitroglycerine, and most contain stabilisers.

Preparation of Sample. Gelatinised powders are ground in a mill of the coffee-mill type (see Abel Heat Test, p. 71). A small portion is passed through and discarded, and the main sample is passed through the sieves as used for the heat test. For general analysis, the material which passes through holes of 0·032 inch diameter is taken.

Some powders in the form of small flakes do not require grinding. Particles of iron may be removed from ground powders by a magnet. For the quantitative analysis the powder is dried at 60° to 70° to remove the solvent. Nitroglycerine powders should not be warmed for more than an hour at 60°. Alternatively, the volatile matter may be determined on a separate portion of the ground powder.

Qualitative Analysis

The nature of the gelatinising solvent can generally be detected by its smell. The powder should then be tested to ascertain whether it is a nitrocellulose powder or whether it contains nitroglycerine. It is digested for a considerable time with ether, decanted, and the solution allowed to evaporate in a dish. If a minute quantity of the liquid is absorbed on a piece of filter paper and struck on an anvil, an explosion occurs if the liquid be pure nitroglycerine. Apart from nitroglycerine, ether extracts stabilisers, nitro-compounds, etc. Camphor is detectable by its smell. Diphenylamine is recognised by the blue colour which it gives with sulphuric and nitric acids. On heating a solution of diphenylamine in 95 per cent. alcohol with a few drops of chlorine water, a green coloration is formed, changing slowly to dark violet on keeping or warming. Mineral jelly may be separated from nitroglycerine by boiling with 80 per cent. methyl alcohol. Substituted ureas and urethanes are also sometimes met with. The aqueous extract is examined for salts, and the ash is also tested.

Quantitative Analysis

Volatile Matter.—This includes the gelatinising solvent and water. In absence of volatile ingredients, such as nitroglycerine, the weighed ground powder may be dried by heating, and then reweighed. Temperatures of 65° to 100° are employed. It is of importance to avoid loss of volatile matter of the ground powder in the cold before weighing. For this reason the powder should not be too finely ground. Some heating takes place during the grinding. In some cases the powder is not ground, but is cut up into pieces, dissolved in ether-alcohol, reprecipitated by water, evaporated and dried in a vacuum at 50° or by heating to 95°-100°. The loss of weight, corrected for any residues in the solvent represents the volatile matter. The object of this procedure is to avoid initial losses of solvent. If a slightly volatile ingredient be present, the estimation may be made by drying at ordinary temperature in a vacuum.

In powders containing nitroglycerine, the volatility of the latter exercises a disturbing effect. To prevent escape of nitroglycerine, the apparatus shown in Fig. 2 is It consists of an aluminium dish A and a conical glass-cover B, the whole apparatus weighing about 40 g. The ends of the sticks of powder are discarded and it is then ground as for the heat test. This should occupy one and a half to two minutes. Approximately 5 g. is weighed out into the dish, which is then covered with the cone, the whole accurately weighed and heated on an iron plate resting on a water bath. After three hours the apparatus is allowed to cool for half an hour in a desiccator, and weighed. The cone should rest closely on the rim of the dish to prevent loss of nitroglycerine. The nitroglycerine condenses completely on the glass cone. Separate determinations of water and organic solvent are not usually undertaken. Distillation with xylene has been used for the estimation of water. Dupré gave a method depending upon the reaction between water and calcium carbide. Pieroni proposed to subject the powder to steam distillation and estimate acetone in the distillate by conversion to iodoform.

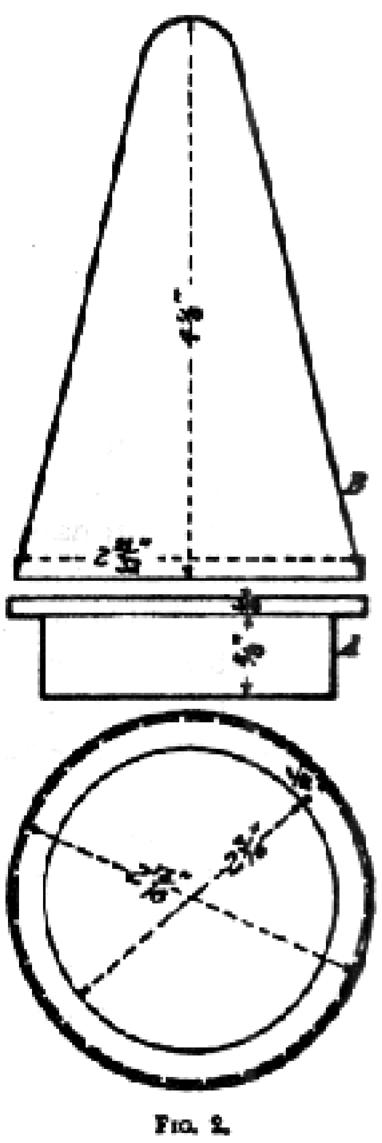

FIG. 2.

Chemical Analysis.—The powder is first extracted in a Soxhlet or other extraction apparatus to separate the nitroglycerine, etc. Pure dry ether should be used; sometimes a little chloroform (10 per cent.) is mixed with the ether to prevent solution of nitrocellulose. The solution is carefully evaporated and the flask is placed on a hot-plate surmounted by a sheet of uralite with holes which do not permit the flask to touch the hot-plate. From time to time the flask is removed and air, at ordinary temperature, is blown through it. This is continued until the weight becomes constant. The nitroglycerine, etc., may also be dried in a vacuum over calcium chloride.

A *nitrogen* determination may then be made by the nitrometer method. Care should be taken in introducing a solution of the substances in concentrated sulphuric acid into the nitrometer, as ether peroxide may give rise to heating and explosion in the bulb.

It is to be observed that the nitrogen determination may be disturbed by mononitrobenzene derivatives, as these are partially nitrated to dinitro-derivatives. Diphenylamine and other stabilisers also affect the results. As the Schulze-Tiemann method is rendered inaccurate by the volatility of the nitroglycerine, it has been proposed to hydrolyse a weighed quantity of the residue with alcoholic potassium hydroxide and estimate the nitrogen by ferrous chloride and hydrochloric acid.

In extracting nitroglycerine with ether and evaporating as above, slight losses of nitroglycerine occur by reason of its volatility. For this reason the nitroglycerine is sometimes estimated by difference. Silberrad, Phillips, and Merriman described a method in which the ether-extract is boiled with sodium ethylate to saponify the nitroglycerine, and the nitrogen reduced to ammonia by powdered zinc and iron.

Mineral jelly or *paraffin* may be separated from nitroglycerine by boiling with 80 per cent. methyl alcohol. This dissolves the nitroglycerine. The solution is filtered and the insoluble portion dissolved in ether, evaporated and weighed. Alternatively the nitroglycerine may be removed by saponification with alcoholic potassium hydroxide, and the solution diluted with water and extracted with ether.

For the *separation of nitroglycerine from nitroaromatic compounds*, Hyde gives a method depending on extraction with carbon disulphide and 65 per cent. aqueous acetic acid. Dickson and Easterbrook recommend separating nitroglycerine from nitro-compounds by dissolving the mixture in methyl alcohol and destroying the nitroglycerine by ferrous chloride solution, after which the solution is extracted with ether. Lutri hydrolyses the nitroglycerine with 20 per cent. sulphuric acid and extracts the nitro-compounds with benzene.

Camphor may be estimated according to Foerster by heating the powder with water on a water-bath and adding sodium hydroxide solution gradually. The heating is continued until the structure of the powder is destroyed. The camphor is distilled over with some of the water into a receiver of special design, in which it is treated with a known quantity of benzene, and natural camphor determined by means of a polarimeter. A gravimetric method is described by Vieth and Bilhuber, in which the powder is hydrolysed as above and the camphor distilled over into a receiver containing ether. After

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repeated extractions with ether, the ethereal solution is dried with calcium chloride and a portion is evaporated.

For the estimation of *diphenylamine* the powder may be saponified as above, and then distilled until all the diphenylamine has passed over. The distillate is extracted with ether, which is separated, dried with calcium chloride and evaporated. The diphenylamine may also be estimated by conversion to tetrabromo-diphenylamine. For this purpose the ethereal solution is evaporated with alcohol, and excess of bromine is added to the alcoholic solution with stirring. The tetrabromo-diphenylamine separates out, and the supernatant liquor should be clear and should smell distinctly of bromine. Water is added and the whole is boiled to remove alcohol and bromine. The bromine compound is filtered off, washed with warm water and dried in a steam oven. The bromination may also be effected by potassium bromate and bromide in acid solution.

Urea derivatives may also be present. Diphenylurea (asymm.) is hydrolysed by strong sodium hydroxide solution and the resultant diphenylamine is estimated.

Centralite is converted to a dibromo-derivative on bromination and may be estimated volumetrically by the bromide-bromate method. Levenson brominates in alcoholic solution. Ellington and Beard use a carbon tetrachloride solution to avoid any interaction between the bromine and the solvent. The reagents consist of (1) 0·2 *N* bromide-bromate containing 5·568 g. potassium bromate and 30 g. potassium bromide per litre, and (2) 0·2 *N* thiosulphate. The propellant is extracted with ether in a Soxhlet using a 200 c.c. reaction bottle as receiver. The ether is then distilled off and the last traces are removed by a current of air. After cooling, 50 c.c. of pure carbon tetrachloride is added and the bottle shaken, whereupon 50 c.c. of bromide-bromate solution and 10 c.c. conc. hydrochloric acid are added. The bottle is shaken for five minutes and 20 c.c. of 15 per cent. potassium iodide added. After vigorous shaking, the solution is titrated with thiosulphate. A blank test is included.

A separation of diphenylamine from centralite may be effected by precipitation of tetrabromodiphenylamine in aqueous alcohol, in which dibromocentralite is soluble.

After the extraction of all soluble ingredients by means of solvents, the *nitrocellulose* remains behind, together with any mineral matter,

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and may be dried and weighed. If necessary the nitrocellulose may be dissolved in acetone (1 litre of acetone to 10 g. of propellant). After allowing to stand, the liquid is decanted and a further portion of acetone added. This is shaken, allowed to stand and decanted. The residue is filtered and the combined acetone solutions are poured into 5 volumes of 1 per cent. aqueous calcium chloride solution. The acetone is boiled off and the precipitated nitrocellulose is collected, washed with hot water, dried and weighed. Chloroform is sometimes used to precipitate the nitrocellulose. A nitrogen determination is made on the nitrocellulose. The nitrogen is also determined in the original powder. It is to be observed that substances such as diphenylamine, camphor, naphthalene, resins, etc., have a disturbing influence on the results of the nitrogen determination. The matter insoluble in acetone may contain carbonates, nitrates, graphite, cellulose, starch and mechanical impurities.

The *mineral matter* (ash) in smokeless powders is estimated by heating carefully in a porcelain dish with a few cubic centimetres of fuming nitric acid on a water bath and evaporating. The residue is then incinerated. Sand may be estimated in the ash by dissolving out the other constituents with warm hydrochloric acid. The ash is also examined for salts of potassium, sodium, calcium, barium and magnesium.

Mercury is estimated as in nitrocellulose. Dupré describes the application of the spectroscopic method to smokeless powders. Hehner gives a method based on precipitation of the mercury by copper and conversion to mercuric iodide. Berkhout gives a method depending on the estimation as metallic mercury.

V. INDUSTRIAL BLASTING EXPLOSIVES

The explosives in use for mining, etc., consist of mixtures of a wide range of oxidising and reducing substances, and the methods of separation can be given only in outline. Some explosives are in the form of powder, others in gelatinous form; in the latter case the gelatinous mass should be cut into thin shavings with a horn spatula to facilitate extraction. Before the examination it is advisable to satisfy oneself that the explosive is reasonably safe to handle. A small portion should be rubbed vigorously in a porcelain mortar with a porcelain pestle.

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Qualitative Examination

Some indications can be obtained by the smell and appearance. Nitroglycol and dinitrochlorhydrin have a faint odour. Some nitrobodies such as mononitrotoluene have a distinctive smell. Charcoal and aluminium are distinctive in appearance.

A small sample should be extracted repeatedly with pure dry ether. After digesting and allowing to stand the ethereal solution is filtered off and allowed to evaporate in a warm place. A small drop of the residual liquid is absorbed on a piece of filter paper and hammered on an anvil. Nitroglycerine explodes with a sharp crack. Nitroglycol and dinitrochlorhydrin behave similarly. Nitric esters give off oxides of nitrogen on gently warming with ferrous chloride and hydrochloric acid. The specific gravity may also be made use of if ether-soluble substances other than these esters are absent.

Camphor remains dissolved in the nitroglycerine and gives a distinctive odour. It can be extracted by carbon disulphide. Sulphur, paraffin wax and resins separate out from the nitroglycerine. Sulphur crystals may be collected and burnt, giving an odour of sulphur dioxide. Paraffin wax is insoluble in cold alcohol. Resins may be separated from nitroglycerine by means of 65 to 70 per cent. acetic acid in which they are insoluble. They can be saponified by boiling with soda solution, and are reprecipitated by acid.

Some aromatic nitro-compounds crystallise out from the nitroglycerine; in certain cases a separation may be effected by extracting the nitroglycerine with 90 per cent. alcohol, in which higher nitro-compounds are sparingly soluble. The nitroglycerine may also be dissolved in 65 per cent. acetic acid, and the nitro-compounds extracted with carbon disulphide.

The residue from the extraction with ether may contain salts, kieselguhr, charcoal, wood meal, nitrocellulose and some undissolved sulphur. The salts are identified by the ordinary reactions; most of them are extractable by water. Carbonates are dissolved by dilute hydrochloric acid with evolution of carbon dioxide. Collodion may be dissolved in ether-alcohol and gun-cotton in ethyl acetate or acetone. The residual ingredients may be identified to some extent microscopically. Starch is detected by the iodine reaction. Wood meal and charcoal may be removed by ignition, leaving such ingredients as kieselguhr, talc, etc.

In some cases salts may be separated by means of their difference in specific gravity, using heavy liquids such as chloroform and bromoform.

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The following list gives the specific gravities of the commoner salts which may be present :—

Salt.	Sp. Gr.	Salt.	Sp. Gr.
Ammonium alum (cryst.) . .	1·62	Manganese dioxide . . .	5·03
" chloride . . .	1·52	Potassium alum	1·75

,, nitrate	1·73
,, perchlorate	1·87
,, sulphate	1·77
Barium nitrate	3·23
Calcium carbonate (precip.)	2·72
,, sulphate (anhydr.)	2·97
,, ,, (hydrated)	2·32
Magnesium carbonate	3·04
,, sulphate (cryst.)	1·68
,, ,, (anhydr.)	2·65
,, chlorate	2·34
,, chloride	1·99
,, perchlorate	2·52
,, sulphate	2·66
Sodium chloride	2·17
,, nitrate	2·26
,, sulphate (anhydr.)	2·66
,, ,, (cryst.)	1·46

In some cases the analysis can be simplified. Thus powdered explosives (ammonium nitrate and chlorate explosives) may be extracted directly with water to remove soluble salts, and the insoluble constituents may be filtered off and identified. Petroleum or mineral oil may separate out from some chlorate explosives. Wood meal remains in suspension. Trinitrotoluene is best extracted with acetone. Aluminium is easily recognisable. Calcium silicide remains behind as a black powder, and evolves silicon hydride on addition of hydrochloric acid. Paraffin wax separates from nitro-compounds on melting and forms a surface layer. Naphthalene is detectable by its smell. Such explosives may also contain small percentages of nitroglycerine.

Quantitative Analysis

In the analysis of nitroglycerine compounds, care should be taken to obtain a thoroughly well-mixed sample, as nitroglycerine may segregate. In sampling, the ends of cartridges should be discarded.

Moisture. This may be determined by evacuation over calcium chloride for twenty-four hours. When nitroglycerine, dinitroglycol, nitrobenzene, or nitrotoluene are present, the method given under Smokeless Powders (p. 50) may be used.

The hygroscopicity is sometimes of importance. It is determined by spreading a weighed quantity of the material on a flat dish, which is then placed under a bell jar over water. The increase in weight is determined at intervals. A control test on an explosive or other material of known hygroscopicity must be included, as the absorption of moisture is affected by the temperature. Hygroscopicity tests may also be carried out on cartridges.

Extraction. The explosive is extracted with pure dry ether in a Soxhlet extractor or a Gooch crucible (preferably in a continuous extraction apparatus). Condensation of water is to be avoided, as this would lead to solution of water-soluble salts. The ether extract, which contains nitroglycerine and allied substances, nitrobenzene and its derivatives, sulphur, oils, mineral jelly, paraffin wax and resins, is allowed to evaporate at about 40° to 45°, taking care to avoid loss of nitroglycerine, etc. Special care should be taken to avoid loss if nitroglycol be present. The evaporation is continued until the weight is constant.

If the nitroglycerine is suspected to contain compounds such as dinitrochlorhydrin, it may be examined by specific gravity, nitrogen content, chlorine content, refractive index. Nitrosugars increase the viscosity and lower the nitrogen content. Hoffman and Hawse give a polarimetric method for nitrosugars.

Tetranitrodiglycerine lowers the nitrogen content of nitroglycerine and is much less readily soluble in 65 per cent. acetic acid. It is also much more viscous than nitroglycerine.

With reference to the nitrogen determination in the nitrometer, it is to be observed that impure ether containing peroxides may give rise to explosions on mixing the extracted substances with sulphuric acid and under other conditions.

It is advisable to mix a small quantity of the extract with sulphuric acid to ascertain whether heat is evolved, and if so, the weighed quantity should be first mixed with sulphuric acid of moderate strength, cooling with ice. Strong sulphuric acid is then added slowly with similar cooling.

Mononitrobenzene and mononitrotoluene give rise to errors in the nitrogen determination, but higher nitro-compounds do not affect it. Naphthalene, diphenylamine, centralite, etc., disturb the nitrogen estimation.

Becker gives a volumetric method for the estimation of nitroglycerine. A solution in acetic acid is boiled with ferrous chloride and hydrochloric acid, and the ferric salt is titrated with titanous chloride, using ammonium thiocyanate as indicator. This is also applicable to dinitroglycol.

Paraffin wax separates out from the nitroglycerine when the ether is evaporated off. It is pressed between filter papers and identified by its form and melting point. To determine its quantity the extract is melted and separated in a warmed separating funnel. Resin may be saponified by hot soda, reprecipitated with acid and weighed, or may be titrated with alcoholic potassium hydroxide, using phenol phthalein as indicator.

The separation of nitro-compounds, camphor, diphenylamine, etc., from nitroglycerine is dealt with under Smokeless Powders (p. 52).

It is sometimes found convenient to remove the whole of the nitroglycerine by heating for several hours with alcoholic potassium hydroxide. Water and ether are then added, and the mixture shaken in a separating funnel. The ethereal solution is evaporated, and the residue consisting of paraffin, mineral jelly or mineral oils, is weighed. The aqueous solution is acidified with hydrochloric acid and bromine is added to oxidise any sulphur. Any separated resin is filtered off and weighed, and sulphur is determined in the filtrate as barium sulphate. Sulphur may also be separated from nitroglycerine by 65 to 70 per cent. acetic acid.

Material Insoluble in Ether. This is dried at a moderate temperature and carefully transferred to a glass dish. It is then further dried at 80° to 90°, or if ammonium nitrate is present, at 70°. If it is in the form of an agglomerated mass, it should be roughly subdivided before drying. Sulphur, if present, may be extracted with carbon disulphide. The residue is then extracted with successive small quantities of water. Warming is sometimes necessary, particularly for the extraction of potassium perchlorate. On the other hand, if aluminium and ammonium nitrate are present, warming must be avoided, or interaction may occur. In addition to salts, the aqueous extract may include soluble matter from wood meal, which may contain as much as 3 per cent. of soluble substances.

Acids resulting from the decomposition of nitroglycerine may form soluble salts by interaction with calcium carbonate, etc. The various salts are estimated by the usual analytical methods. If perchlorates or other salts containing chlorine are present in conjunction with ammonium salts it is not permissible to remove the ammonium salts by direct heating, as this may lead to losses of chlorine. The residue insoluble in water is extracted with dilute hydrochloric acid to dissolve calcium carbonate, magnesia, zinc oxide and metals. If starch is present it should be hydrolysed by boiling with dilute acid.

The residue remaining insoluble in dilute acid may contain insoluble salts, kieselguhr, wood meal, etc. If nitrocellulose is present, the residue is shaken with ether-alcohol to determine the collodion. The ether-alcohol solution is allowed to settle, and an aliquot portion is withdrawn and evaporated. Gun-cotton, if present, is dissolved in acetone, and the solution evaporated. Acetone dissolves certain constituents of wood meal; errors due to this may be avoided by evaporating the acetone solution to 20-25 c.c. and diluting with 100 c.c. of hot water, which precipitates the nitrocellulose. The residue is washed several times with the solvent and finally dried and weighed. It is thus also possible to determine the nitrocellulose by difference.

The insoluble residue may contain charcoal and other carbonaceous matter such as wood meal, etc. These are removed by incineration, and the residual ash contains mineral matter such as kieselguhr.

Nitrostarch is somewhat soluble in ordinary ether containing small quantities of alcohol. For this reason petroleum ether is sometimes used to extract oils, resins and sulphur. The insoluble portion is extracted with water to remove soluble salts and the nitrostarch is then separated from insoluble matter by means of acetone.

In some cases the analysis can be shortened (ammonites, chloratites). A weighed quantity is digested with acetone which readily dissolves nitro-compounds, nitroglycerine and hydrocarbons. The insoluble residue is further tested as above, the salts being extracted with water, and the insoluble residue examined for wood meal, charcoal, aluminium, silicides and mineral matter.

VI. INITIATORS

(a) Mercury Fulminate

$HgC_2N_2O_2$. Mol. wt., 284·6; sp. gr., 4·42; soluble in 100 parts water, 0·07 at 12°, 0·77 at 100°.

Mercury fulminate forms a white to greyish-brown crystalline powder. It is still the most important initiatory explosive. It is very sensitive to shock or friction and must be handled with great care. Goggles should be worn and should be tested beforehand to ensure their resistance to explosive shock. On heating, it explodes at about 150° to 160°, but may explode on more prolonged heating at 100°. The influence of heat in a vacuum on mercury fulminate under various conditions has been exhaustively investigated by Farmer. Mercury fulminate is insoluble in most organic solvents, but dissolves with decomposition or formation of double compounds in ammonia, iodides, cyanides, thiocyanides, thiosulphates, pyridine, etc.

Mercury fulminate should be at least 98 per cent. pure. It should be neutral, practically free from oxalates, chlorides and metals other than mercury.

The moisture is determined by drying over calcium chloride in a desiccator at ordinary temperature and pressure.

In the determination of the insoluble matter the solvent used may be either pyridine, or an aqueous solution of sodium thiosulphate or potassium cyanide. The residue should be carefully dried to avoid loss of mercury by volatilisation.

Free mercury may sometimes be detected as tiny globules. A more sensitive test is to warm the fulminate in a test tube in which a strip of gold leaf is suspended. Metallic mercury shows itself by the formation of spots of amalgam on the gold leaf. For the quantitative estimation, the residue insoluble in pyridine is treated on a filter with a solution of 3 g. potassium iodide and 6 g. sodium thiosulphate in 50 c.c. water. This converts any organic mercury compounds to mercuric iodide, which is soluble in thiosulphate. The insoluble matter is dried at 80° to 90° and weighed. This is taken as mercury. Nicolardot and Boudet shake the fulminate with a 5 per cent. solution of ammonium hydrosulphite and report the residue as metallic mercury.

The fulminate value is best determined by the method of Brownsdon. For the determination, 0·3 of the sample is wetted with about 5 c.c. of water, and 50 c.c. of a solution containing 6 per cent. KI and 2·5 per cent. $Na_2S_2O_3$ (cryst.) is added. The mixture is shaken for about a minute and then neutralised to methyl orange with *N*/10 HCl. The solution and titration should not occupy more than about three minutes as the titre alters rapidly. For the calculation 4HCl is equivalent to $HgC_2N_2O_2$.

The total mercury may be estimated, if required, by precipitation with ammonium sulphide. Losanitsch described an electrolytic method.

Oxalates are estimated by dissolving the fulminate in ammonia, precipitating with ammonium sulphide and determining the oxalate in the filtrate. Alternatively the fulminate may be dissolved in 20 per cent. ammonia and acetic acid added to precipitate most of the fulminate. The oxalate is then determined in the filtrate. According to Rathsburg, mercury fulminate should not decolorise *N*/50 permanganate.

(b) Lead Azide

$Pb(N_3)_2$. Mol. wt., 291; sp. gr., 4·80; soluble in 100 parts water, 0·03 at 18°, 0·09 at 80°; sparingly soluble in organic solvents.

Among the initiating explosives lead azide is second in order of importance. It forms fine white crystals, but these tend to increase in size in contact with water and may explode spontaneously. On heating it explodes at 320° to 340°.

The content of lead azide should be at least 95 to 97 per cent. Usually a little basic azide is present, and this is sometimes preferred, as it is stated to render the material safer. Metals other than lead should be present only in traces. The lead azide should dissolve practically completely in dilute nitric acid. It should be free from acid.

The moisture is determined by drying over calcium chloride or sulphuric acid.

The total lead content may be estimated by evaporating with sulphuric acid on a water bath, and then gradually heating more strongly.

The azide value may be determined by shaking with dilute nitric acid until dissolved and precipitating as silver azide with excess of standard silver nitrate. A little sodium acetate is added to decrease the solubility of the silver azide. The excess of silver nitrate is titrated with thiocyanate. The hydrazoic acid may also be distilled off after addition of acetic acid or ammonium nitrate and estimated as silver azide.

Gasometric methods are also sometimes used.

Azides and hydrazoic acid may be detected qualitatively by the red colour which they give with ferric salts.

Among other substances suggested as initiators are tetrazole derivatives, cyanuric triazide, lead trinitroresorcinate, hexamethylene triperoxidediamine and others. Normal lead dinitrosalicylate has a sensitiveness to shock substantially equal to that of mercury fulminate.

(c) Detonator and Cap Compositions

(i) Detonator Compositions. If the composition is contained in a metal capsule, great care is necessary in the removal of the contents, as the materials are very sensitive. It is advisable to carry out the operation by mechanical means from behind a steel screen. In some cases the detonator is cut open, in others it is squeezed with pliers under precautions to loosen the contents which are then tipped out. The composition may also be loosened by rolling the detonator carefully between two pieces of smooth hardwood board. In opening electric detonators, Taylor and Rinkenbach recommend cutting into the sulphur filling and asphalt and then peeling the copper down in a spiral until the plugs are loosened enough to be withdrawn easily. The portion of the shell containing the charge should on no account be cut into.

It is of importance to observe whether the contents of a detonator consist of one layer of composition or whether they have also a separate layer of a nitro-compound. In the latter case the two layers should be separated mechanically as completely as possible. The approximate weight of the filling should be determined.

The moisture content is not usually determined; it is generally very low. The efficiency is, however, strongly affected by moisture, and the estimation may be made, if required, by drying for three days over sulphuric acid in a vacuum desiccator. A small beaker of mercury should be inserted to prevent evaporation of metallic mercury from fulminate.

The analysis of simple fulminate-chlorate mixtures may be effected by extraction either with water or with pyridine. In the former method the mixture is digested with cold water, and the residue is washed on a filter. The mercury fulminate is dried at 50° for three hours and weighed. Some fulminate dissolves in the water. This is estimated by precipitation as sulphide. The chlorate may also be determined in the filtrate. The solution is boiled with nitric acid and then treated with formaldehyde and silver nitrate. Silver chloride is precipitated and the estimation may be made gravimetrically or by Volhard's method.

Mercury fulminate is soluble in pyridine and may be extracted, leaving the chlorate undissolved. The latter is washed with ether, dried and weighed. Small quantities of impurities in the fulminate remain undissolved; these may be separated from the chlorate by extraction with water. The fulminate may be separated as sulphide after diluting the pyridine solution with water.

Binding material may be present in small quantities and is estimated by difference.

In the analysis of composite detonators containing fulminate-chlorate with tetryl or trinitrotoluene the two layers are separated mechanically; the fulminate-chlorate is dealt with as above, and the nitro-compound is examined for melting point, acidity and possibly nitrogen content. If it is not found possible to separate the two layers satisfactorily, composite tetryl detonators may be dealt with as follows: The contents of two or three detonators are extracted with water, which dissolves the chlorate and a little fulminate. These are estimated in the aqueous solution as above. The filter and its contents are dried for five hours at 70° and weighed. The fulminate is dissolved out with warm 30 per cent. hydrochloric acid, followed by five washes with water. The residue is dried for three hours at 110° and weighed. If it is required to estimate insoluble impurities, the tetryl may be dissolved in acetone or benzene.

In the examination of composite detonators containing lead azide in conjunction with trinitrotoluene or tetryl, the primary and secondary fillings are separated mechanically and tested. If it is not found possible to separate the two layers they are mixed together and the nitro-compound is extracted with absolute ether, orthonitrotoluene or other suitable solvent. The insoluble lead azide is dried at 70° and weighed. If lead trinitroresorcinate is also present, the content of lead and of azide-nitrogen is determined.

(ii) Cap Compositions.—Percussion caps are required for ignitory purposes in fire-arms and thus differ from detonators. Antimony sulphide is frequently added for this purpose. Ignitory compositions are much more varied in nature than detonator compositions and are often complex in character. Mercury fulminate is frequently used as a constituent, but some are free from fulminate.

The compositions are very sensitive, but the charge is much smaller than in detonators, and consequently they can be handled without serious risk. It is usually necessary to extract the charges of several caps to obtain enough material for the tests. The hands should be protected by heavy gloves or cloth.

The compositions vary so much that a general scheme for the identification of ingredients cannot be given.

The weight of charge is determined by emptying a sufficient number of caps and weighing them before and after emptying. If tinfoil is present, the small discs are carefully cleaned and weighed with the empty caps. Moisture is not usually determined; if necessary it may be estimated by drying in a vacuum over sulphuric acid.

A simple cap composition containing mercury fulminate, antimony sulphide, potassium chlorate and glass powder may be analysed by successive extractions with warm pyridine to dissolve fulminate and shellac, water to dissolve potassium chlorate, hydrochloric acid or aqua regia to dissolve antimony sulphide. Glass powder remains undissolved. The mercury, antimony and chlorate may be determined in the extracts.

The following method is given by Taylor and Rinkenbach for single primers. The fulminate is estimated by the thiosulphate method (see under Mercury Fulminate, p. 60). After the titration the supernatant liquor is decanted through a filter, and the antimony sulphide washed five times with hot water by decantation. The filter is dried and the sulphide on it is dissolved with hot hydrochloric acid, the filtrate being collected in the dish containing the bulk of the antimony sulphide. This is heated to expel hydrogen sulphide. About 1 g. of tartaric acid is added and the solution is transferred to an Erlenmeyer flask. Ammonia is added until the solution is nearly neutralised, but no excess should be added. The neutralisation is completed with solid sodium bicarbonate and an excess of 0·05 g. is added. The solution is then titrated with $N/100$ iodine solution and starch.

If ground glass is present, it remains as an insoluble residue which may be determined. The potassium chlorate is determined by difference. Heaven precipitates the mercury from the thiosulphate solution as sulphide, reduces the chlorate with ferrous sulphate and titrates the chloride formed.

Taylor and Rinkenbach give a method for such compositions, in which a sample is heated with dilute sulphuric acid and the sulphides of mercury and antimony are precipitated with hydrogen sulphide. The filtrate is evaporated, the chlorate being decomposed. The evaporation is completed in a platinum dish, and the residue is finally ignited. The potassium sulphate is weighed. The sulphides are dissolved in hydrochloric and nitric acid with addition of tartaric acid. Glass powder remains undissolved and is filtered off. The sulphides are again precipitated and separated by ammonium sulphide. The mercury is determined as sulphide, and the antimony solution is oxidised with nitric acid.

VII. Physical and Explosive Tests

The chemical analysis of explosives is frequently supplemented by physical tests. These may be combined with storage trials at ordinary temperature or under warm conditions to find whether alterations have taken place with regard to hardening, conglomeration, exudation, absorption of moisture, efficiency or stability.

Density. The method for gun-powder and similar powders is given on p. 30. The density of blasting explosives in cartridge form may be estimated by weighing and measuring the cartridges. Another approximate method is to measure the displacement of sand. A glass tube is filled with sand and weighed. It is then emptied and a weighed stick of the explosive is inserted. Sand is poured in until the tube is full. The sand is levelled off and the whole is weighed. The apparent density of the sand is determined separately in the same tube.

Tendency to Segregate. Mixed explosives may tend to separate to some extent into their ingredients by shaking or by alternations of moisture in the atmosphere. The effect of shaking may be determined by putting a quantity of the explosive into a wide-mouthed bottle, so that the bottle is partially filled. The bottle is corked and shaken in a mechanical shaker for an hour. The explosive is then examined for visible signs of segregation and separate portions may be taken out and examined for differences in ease of ignition, etc. The effect of moisture is ascertained by exposing a sample in a flat dish for alternate periods of twenty-four hours to moist and dry air and examining after a week for efflorescence of crystals.

Movement of nitroglycerine in a cartridge by gravitation is tested by keeping the cartridge in a vertical position for some weeks at 32°. Portions from the two ends are examined for nitroglycerine content before and after the test, which may be carried out in dry or moist air.

Exudation. This refers mainly to nitroglycerine explosives. Exudation is undesirable, as the liquid nitroglycerine which exudes out may become exploded by friction or shock. The exudation can be measured by placing a cylinder of the explosive on porous paper in a warm oven and ascertaining the amount of liquid which sweats out. A typical explosive is taken as a control. In a test prescribed by the Home Office, a cylinder is cut from the cartridge, such that the length is about equal to the diameter. The ends are cut flat and the cylinder is placed on a flat surface and secured by a pin. It is then kept at 85° to 90° F. for six days and nights. The cylinder must not decrease by more than a quarter of its height, and the upper surface must retain its flatness and the sharpness of its edges. Sometimes pressure is applied to facilitate the exudation, and centrifuging has also been applied. To test the exudation due to freezing, the cartridges are frozen and thawed three times. Exudation is also met with in nitro-compounds which form eutectic mixtures.

Inflammability. A small sample of the explosive is filled into a glass or paper tube about 2 cm. in diameter. The exposed surface is smoothed, and a slow fuse is brought in contact with it and ignited, to ascertain whether the explosive inflames and whether it burns partially or completely. The test should be repeated on several samples. The ease of inflammation may also be measured by playing a small bunsen flame on to the explosive for a measured time, say ten seconds. Considerable differences are observed between different explosives. Control samples of known explosives should be included for comparison. Another method is to fasten a small quantity of the explosive to the end of a pendulum which swings through a flame in such a way that the time can be measured.

If the explosive has withstood the test in which it is exposed to the flame from a slow fuse, it is further tested by dropping a portion of 0·5 g. into a red-hot iron basin 12 cm. in diameter. The quantity may be increased to 5 g. if no explosion occurs. The basin must be well cleaned after each test and should be frequently renewed; on the other hand a new basin does not give quite normal results, until it has been used once or twice.

In some cases, larger quantities of a pound or two are burnt in a wood fire to ascertain the degree of danger to which the explosive may give rise in case of fire. The observations should be made under precautions at a safe distance.

Ignition Temperature. This is usually determined by placing 0·1 g. of the explosive in a small test tube, which is then corked and placed in a fusible metal bath at 100°. The temperature is raised 5° per minute until inflammation or explosion occurs. The quantity and rate of heating differ in different countries.

Sensitiveness to Shock and Friction. The sensitiveness to blows is measured by the falling weight test. The explosive must be finely divided and well dried. A small portion is spread in a thin layer on an anvil. A bolt rests on the explosive and a cylindrical weight is allowed to fall upon it from a measured height. If explosion occurs the test is repeated with a lower height of fall until the mean height is found at which explosion just occurs. A standard explosive which can be obtained in pure condition, such as picric acid, is taken as a control. Considerable difficulty has been met with in obtaining reproducible results. An improved method was introduced by Rotter in which the results of each impact are evaluated, not by personal judgment but by a quantitative measurement of the gas produced by the decomposition of the explosive. A number of typical results are quoted by Robertson. The sensitiveness to friction may be tested qualitatively by rubbing a small portion of the explosive vigorously in an unglazed mortar with an unglazed pestle. A useful test is to strike a glancing blow with a mallet, the explosive being laid on anvils of different materials. A broomstick may also be used, the explosive being struck with the end by a blow in which the broomstick is moved in the direction of its axis at an angle of about 60° to the anvil. A more scientific test on these lines is described by Howell. His apparatus consists of a steel anvil with grooves to hold the explosive (7 g.), and a swinging shoe which is allowed to fall with a circular motion from various heights.

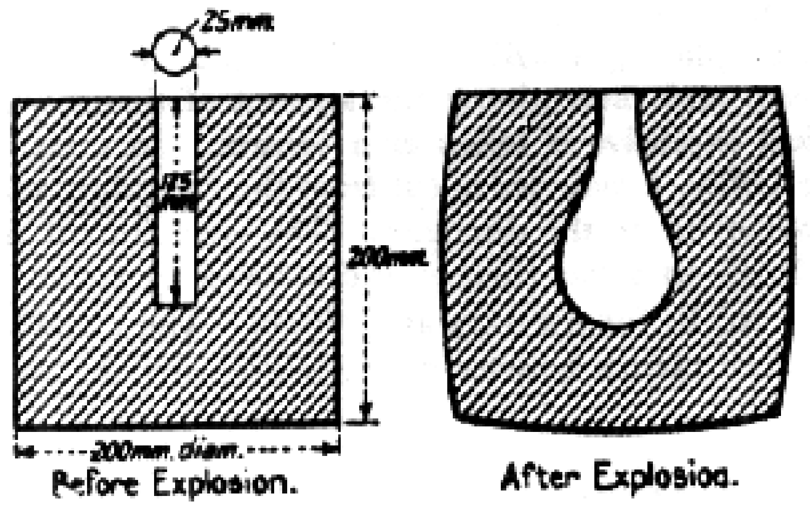

Fig. 3.

Lead Block Test. This is one of the oldest tests for the explosive power, and is still widely used. The explosive is fired in a cavity in a cylindrical lead block. The cavity becomes enlarged and the increase of volume is taken as a measure of the power. Standard conditions were laid down at the Fifth International Congress of Applied Chemistry. The lead block (Fig. 3) is cylindrical and is 200 mm. in height and 200 mm. in diameter. The cylindrical cavity is 125 mm. deep and 25 mm. in diameter. Ten g. of explosive wrapped in tinfoil is taken for the test, and tamped with sand. The charge is fired by a detonator, and the expansion is measured by finding the volume of water necessary to fill the cavity. The original capacity of the bore is deducted and allowance should be made for the expansion due to the detonator. The purity of the lead and the temperature of casting of the blocks affect the results to some extent.

Ballistic Pendulum. A heavy mortar is suspended from a bearing and a stemmed shot is fired into it from a steel gun. The degree to which the pendulum swings gives a measure of the energy imparted to it. The weight of the mortar and height of suspension differ in different countries, *e.g.* at Rotherham 5·025 tons at 92 in., in America 14·1 tons at 89·75 in. The gun is brought to a measured distance from the mortar and fired electrically. Charges of $\frac{1}{4}$ to $\frac{1}{2}$ lb. of explosive are used, and a standard explosive is taken for comparison.

In another method a heavy mortar, firing at an elevation of 30°, is used. The explosive is detonated by means of a slow fuse and propels a projectile weighing 15 kg. The distance to which this is thrown is measured.

Brisance Meter. In using this apparatus, the violence of the explosive effect is measured by the crushing of a metal cylinder. The explosive is detonated on a steel plate, covered by two lead discs for protection. The steel plate is 2 cm. thick, weighs 320 g. and is supported by a piston fitting into a hollow steel cylinder. The lower end of the piston rests on a copper cylinder supported by the steel base. The detonation of the explosive transmits a pressure through the piston to the copper cylinder, and crushes it to an extent which can be measured. The degree of crushing is used to compare the brisance of different explosives.

Rate of Detonation. Two methods are in use. In the direct method, the time of detonation of a measured length of a column of explosive is determined. This necessitates the accurate measurement of very short time intervals, which is effected by means of a rapidly rotating drum fitted with a speed recorder. The column of explosive is fitted with wires at a fixed distance apart, generally one metre. The rupture of the wires gives rise to induction sparks, which give spots on the smoked surface of the drum. By measuring the distance between the spots, the rate of detonation can be calculated. The velocity depends upon the diameter of the train of explosive up to a limiting value, the degree of confinement, the density, and the method of initiation.

An alternative method is that of Dautriche. This method is a comparative one and necessitates a knowledge of the rate of detonation of a standard explosive enclosed in a detonating fuse. The explosive to be tested may be in cartridges or compressed into a tube; a detonator is inserted at one end (Fig. 4). Two other detonators are inserted into the sides of the tube at a known distance apart, and connected to a loop of the detonating fuse. When the explosive is detonated the detonation is transmitted successively to the two ends of the detonating fuse, and the two waves meet at a point depending on the rates of detonation of the main explosive and of the explosive in the detonating fuse. The point at which the waves meet is ascertained by the indentation of a slab of lead on which the detonating fuse lies.

The sensitiveness to detonation is determined by subjecting the explosive in its usual form (*e.g.* in cartridges) to the action of detonators of different intensities. These are fired electrically, and the effect on

the explosive is observed.

In order to ascertain the propagation of detonation, two cartridges are placed end to end on the ground at a certain distance apart, and one of them is detonated. By varying the distance it can be ascertained at what distance the first cartridge is able to detonate the second.

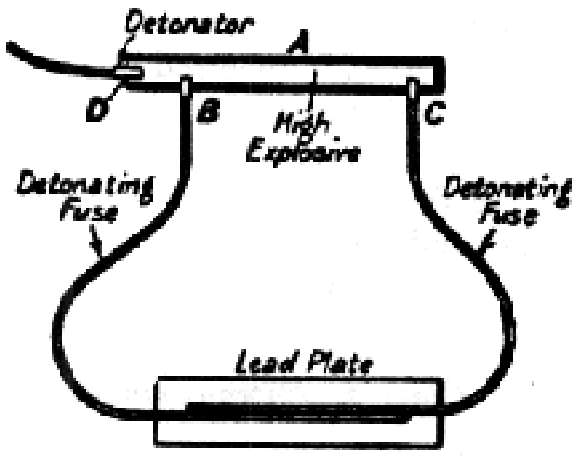

FIG. 4.

Length and Duration of Flame. **These are of importance in connection with the ignition of fire-damp, etc. The measurements are made photographically. A sensitive film is fixed to a drum, which is rotated at a known speed, and the flame is photographed through a narrow slit in such a way that the height of the image shows the length of the flame and the breadth shows its duration.**

Testing of Detonators. **The initiating action may be determined by the Esop and Wöhler tests in which the detonator is fired in contact with an explosive which has been partially deadened by the addition of an inert substance. Tests are also made to determine the limiting charge of a detonator composition, which just suffices to bring about detonation. In the "Sand test" of the U.S.A. Bureau of Mines, a detonating charge is exploded in a mass of carefully graded sand and the degree of pulverisation caused by the explosion is measured.**

In the "Nail test" the detonator is attached by means of wire to a nail, the two being parallel and the lower end of the detonator being level with the centre of the nail. The power of the detonator is measured by the degree of bending of the nail. Standard nails must be used for the test.

The Trauzl test is sometimes used with a smaller lead block. The indentation of a lead plate is also frequently made use of. Methods for caps are given by Brownsdon. These include photographs of the flash with the help of a revolving perforated disc, to determine the length and duration of flash, measurements of the heat evolved and the volume of gas generated, in a special apparatus.

C. STABILITY TESTS

Nitric esters undergo gradual decomposition on storage. Stability tests are therefore necessary as a control of the safety of explosives of this type. The tests are applied during manufacture and to the finished explosive; and they may also be applied at intervals during storage, especially in hot climates.

The usual procedure in stability tests is to subject a sample of the explosive to a raised temperature in order to increase the rapidity of the decomposition and obtain a quick indication of the stability. After heating at constant temperature for a certain length of time, the degree of decomposition is measured by one of the following methods :—

(1) By indicators depending on the action of nitric peroxide.
(2) Direct observation of brown fumes.
(3) Measurements of spontaneous heating.
(4) Methods depending on the explosion of the sample.
(5) Quantitative estimations of decomposition products.
(6) Loss of weight.
(7) Gasometric methods.
(8) Acidity measurements.

The most reliable procedure is to carry out a heating trial at a temperature not far removed from the temperature of storage, but this necessitates a prolonged trial in order to bring about a measurable degree of decomposition, and is not always practicable.

I. STABILITY TESTS DEPENDING UPON INDICATORS FOR NITRIC PEROXIDE

(a) Abel Heat Test

This is the oldest test, but is still widely used. It depends upon the colorimetric estimation of traces of nitrous acid or nitric peroxide by test papers prepared with potassium iodide and starch. The explosive is contained in a test tube which is heated to a constant temperature, the test paper being suspended over the explosive. The following are the main requirements. Apparatus of the standard patterns can be obtained from chemical apparatus dealers.

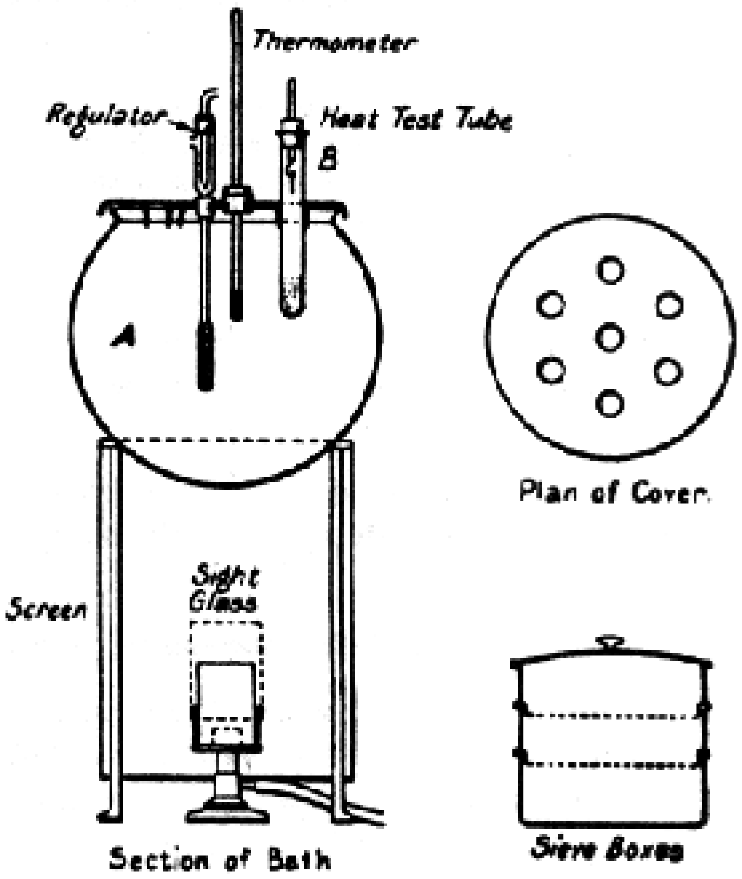

FIG. 5.

Heating Bath (Fig. 5). The bath consists of a spherical copper vessel 7⅝ in. diameter with an aperture of 5⅜ in. It has an overflow pipe ⅜ in. below the top. The lid is of copper about 6 in. in diameter and has 7 holes, one for a thermometer and six for the glass tubes. These are held in position by wire supports fixed to the lower side of the lid. The bath rests on a tripod stand surrounded by a screen, and is heated by an Argand burner with a copper chimney.

Test Tubes. These are of glass, without lips, and are 5⅜ to 5½ in. in height. They are of such diameter that they will hold 20 to 22 c.c. of water when filled to

a height of 5 in. They are etched with short lines at 3, 3⅜ and 5 in. from the bottom. Rubber rings are provided which fit round the test tubes and rest on the bath lid.

Rubber Stoppers. These fit the test tubes; they are perforated and carry a glass rod, terminating at its lower end in a platinum hook to hold the test paper.

Dropping Bottle. This is for moistening the test papers with glycerine water. It is of brown glass and has a glass stopper which is drawn out to a thin-pointed rod, which dips into the liquid.

Lead Discs. To cover any holes in the lid which are not occupied.

Caps for Test Tubes. These are of black paper; they are of cylindrical shape and fit loosely over the tubes to exclude light. They have holes near the top and bottom to permit of convection of air.

Cordite Mill. This is of the coffee-mill type with a fluted grinding surface.

Cordite Cutter. A standard pattern of knife of the lever type is prescribed for cutting up cordite, etc.

Sieves. A circular brass or copper nest of sieves of standard dimensions is used. Ground cordite is collected between two sieves, consisting of sheets of brass drilled with holes 0·08 and 0·032 in. in diameter respectively. The lower sieve fits into a circular box, and the upper sieve has a domed lid.

Rectangular Sieve (for nitrocellulose). A brass frame of internal dimensions 7⅝ in. by 5½ in. is covered with tinned brass wire gauze with 10 meshes per inch.

Test Papers. These are prepared by dipping filter paper in a solution of starch and potassium iodide. The sensitiveness depends so much upon the paper used and the conditions of preparation that it is advisable to obtain them from a standard source.

The test papers are prepared as follows: 220 c.c. of freshly distilled water is placed in a flask of Jena glass and raised to boiling over a spirit lamp burning pure spirit. Three g. of pure starch (cornflour) previously purified by washing six times by decantation with pure water and carefully dried, is suspended in 30 c.c. of pure water and poured into the 220 c.c. of boiling water with continuous shaking. The whole is boiled gently, with shaking, for five minutes. The starch solution is then added to a solution of 1 g. of pure potassium iodide in 250 c.c. of freshly distilled water. After standing overnight in a dark room, the clear supernatant liquid is carefully syphoned off and used at once for dipping the paper. The filter paper should be of pure cotton cellulose, free from size or loading and from all trace of impurity. The prescribed thickness is 0·18 mm. Sheets of the paper are passed singly through the iodide starch solution, which is contained in a porcelain tray. Each sheet is then held vertically over the tray, and excess solution is removed from the edges by a glass rod. The sheets are then hung up to dry in the dark. They are afterwards cut into strips 1 cm. by 2 cm., the edges of the paper being discarded. Freedom from laboratory fumes is essential in all these operations. The papers are allowed to mature for a month or more in the dark before use. They are preserved in brown glass bottles. To confirm that test papers are still serviceable after keeping, a drop of dilute acetic acid is placed on the paper; this should give no coloration for some time.

Standard Tint Papers. 0·48 g. of the finest yellow ochre, 0·2 g. of raw umber and 5 g. of fine gum arabic all finely ground are shaken with 100 c.c. of cold water until the gum has dissolved. The suspension is then well shaken and allowed to stand for an hour. Lines are ruled on filter paper with this suspension which is then cut up into strips 1 cm. by 2 cm. The breadth of the line must be between 0·5 and 1 mm.

Preparation of Samples for Test. Great cleanliness of the hands and all apparatus should be observed. Undue exposure of the explosives to light should be avoided in all the operations, and the test should be carried out without delay when the sample is prepared.

A. *Explosives of Class 3, Nitro-compound, Division I*

1. *Dynamite and other Nitroglycerine Preparations from which the Nitroglycerine can be extracted by Water as below.* A glass funnel (5·5 cm.) is fitted with a filter paper. The explosive is loosened from its cartridge; 13 g. is placed in the funnel and pressed down fairly tightly with a flat-ended glass rod. The funnel is placed in a heat-test tube and filled up with distilled water. The stem of the tube must not touch the side of the heat-test tube. The water displaces nitroglycerine from the dynamite, and when 2 c.c. of nitroglycerine have collected in the tube the extraction funnel is removed. No water must pass into the heat-test tube. The sample is then ready for heat test.

2. *Carbonite, Monobel Powder, and similar Friable Nitroglycerine Preparations from which the Nitroglycerine cannot conveniently be extracted as above.* The contents of the cartridge are loosened, and 3·2 g. weighed into a scoop and transferred by means of an aluminium funnel to a heat-test tube, collected at the bottom by tapping gently and pressed down to a height of 3 cm. with a flat-ended glass rod.

3. *Blasting Gelatine, Gelatine Dynamite, Gelignite, and Analogous Preparations.* The wrapper is opened, about half an inch of the end of the cartridge is cut off and discarded, and a portion weighing approximately 3·2 g. then cut off, avoiding contact with the hands. The portion is placed on the scoop and the weight is adjusted to 3·2 g. This is then transferred to a mortar and 6·5 g. of French chalk added. The explosive and French chalk are worked together with the pestle. This should require a half to one and a half minutes. The mixture is then ground by a circular movement of the pestle for half a minute, and should then be homogeneous in appearance. The mixture is transferred to a heat-test tube with the help of a horn spatula and aluminium funnel, and gently pressed down with a flat-ended glass rod to a height of 5 cm.

4. *Cordite, Ballistite and other Propellants of Class 3, Nitro-compound, Division I.* (*a*) Explosives in the form of sticks or tubes. The sticks or tubes are wiped with clean filter-paper and are cut into small pieces about ⅛ in. long with the cordite knife, ½ in. being rejected from each end of the stick or tube. The set of sieves is placed under the mill, and the cut sample is ground. The first portion is rejected and a sufficient quantity of the sample is to be taken to ensure that the portion collected between the two sieves will suffice for the test. The nest of sieves is closed and shaken for one minute. The material collected on the second sieve is taken for the test, except that when the nominal diameter of the sticks or tubes is less than 0·03 in. the material from the bottom compartment is to be taken for the test. 1·6 g. is weighed out in the scoop, transferred by means of an aluminium funnel to a heat-test tube and shaken down by tapping the tube with the fingers.

(*b*) Explosives in the form of grains for small arms: 1·6 g. is weighed into the scoop and transferred by an aluminium funnel to the heat-test tube. Three such samples are weighed out.

B. *Explosives of Class 3, Nitro-compound, Division 2*

1. *Nitrocellulose Pulp.* Six thicknesses of filter paper are laid on top of one another. Sufficient of the sample to give about 5 to 6 g. after the final pressing is spread on the top sheet. Six other thicknesses of filter paper are similarly laid over the sample. The whole is then placed under pressure (*e.g.* in a hand-screw press) for about three minutes. The sample is then removed, rubbed up by hand on the filter paper and again pressed for three minutes on fresh filter paper. It is then transferred to the rectangular 10-mesh sieve and rubbed through it with the hand. Five g. is weighed out and spread evenly on an aluminium tray. The tray is placed in the oven, which should be at 120° F. (48·9° C.), and is kept there for fifteen minutes with the door closed. It is then removed and the sample is transferred to the top sieve of the nest of sieves. It is sieved, with the lid on, for two minutes. For this operation the second sieve is not used. The portion which passes through is again spread on an aluminium tray and exposed to the air of the room for four hours. 1·3 g. is then weighed into the tube with the aid of the scoop and aluminium funnel. Two such quantities are taken. The material in each tube is pressed down with a flat-ended glass rod to a height of 3 cm.

2. *Compressed Gun-cotton for Torpedo Warheads and Mines.* About 10 g. is removed from the centre of the primer or slab by scraping with a horn spatula. The scrapings are placed in a glass beaker of 1500 c.c. capacity, two-thirds full of distilled water, and stirred frequently for fifteen minutes. After settling, the water is poured off and replaced by the same quantity of water. It is again stirred for fifteen minutes, allowed to settle and decanted. The sample is collected by hand and the excess of water squeezed out. The wet gun-cotton is spread on six thicknesses of filter paper. Six other filter papers are laid on top and the sample is treated as described above for nitrocellulose pulp.

3. *Tonite and Analogous Nitrocellulose Preparations.* The sample is held over the rectangular sieve, and sufficient for the tests is scraped

out from the centre of the cartridge with a horn spatula. The material is rubbed through the sieve by hand, and spread evenly on an aluminium tray. This is placed in the oven at 120° F. (48·9° C.) for fifteen minutes with the door closed. It is then removed and the sample transferred to the top sieve of the nest of sieves. It is sieved for two minutes with the lid on. For this operation the second sieve is not to be used. The sieved material is again spread on an aluminium tray, and exposed to the air of the room for four hours. 1·3 g. is weighed out on a scoop and transferred by an aluminium funnel to a heat-test tube. Two such quantities are spread out. The material is gently pressed down with a flat-ended glass rod to a height of 3 cm.

4. *Nitrocellulose Propellants.* (*a*) Explosives in the form of sticks or tubes: the procedure as for cordite in sticks or tubes is followed. (*b*) Explosive in the form of grains for small arms. A quantity sufficient for the tests is spread evenly on an aluminium tray. This is placed in the oven at 120° F. (48·9° C.) for fifteen minutes with the door closed. It is then removed and exposed to the air of the room for four hours. Three quantities of 1·3 g. each are weighed out with

a scoop, transferred by an aluminium funnel to heat-test tubes, and shaken down by tapping the tubes with the fingers.

5. *Ammonite, Bellite, Roburite, etc.* The contents of the cartridge are loosened. The first half inch is rejected, and 1·3 g. loosened into the scoop and transferred by means of an aluminium funnel to a heat-test tube.

C. *Explosives of Class 4, Chlorate Mixtures, Divisions 1 and 2*

These are treated as under Class 3 (p. 74).

Application of the Test. The heating bath is filled with water up to the outflow. It is placed in a north light in such a position that the papers can be observed by reflected light. The temperatures for the test with various explosives are given below.

The glass rod with platinum hook is inserted in the rubber stopper. A test paper is then held with forceps and pierced near the top with a needle. A small quantity of a mixture of equal volumes of glycerine and water is applied to the upper edge of the paper by means of the glass rod of the dropping bottle, so that it will moisten the upper half of the paper by the time the test is complete. The wetting of the paper requires considerable practice to ensure uniformity. The paper is then affixed to the platinum hook. At no time should the paper be touched with the fingers. The rubber stopper carrying the test-paper is inserted in the test tube containing the explosive, so that the bottom of the stopper coincides with the top line etched on the tube, and the position of the glass rod is adjusted so that the lower edge of the wet portion of the test paper coincides with the middle etched line on the test tube. The lower edge of the wet portion should be approximately horizontal. The test tube is then inserted in one of the holes of the bath so that the bottom line etched on the tube coincides with the lid of the bath. The tube should be fitted with a rubber ring flush with the lid of the bath. The cap is placed over the tube. The cap is lifted at intervals to observe the test paper, but should not be lifted unnecessarily. The test is completed when the faint brown line which appears on the paper becomes equal in depth of tint to the standard tint. The time is measured from the introduction of the tube into the bath, to the production of a tint equal to the standard tint. The following table summarises the limits for the different explosives :—

Abel Heat Test: Quantities, Temperatures and Time Limits

	Temperature.		Quantity.	Time Limit.
	Degree F.	Degree C.		Minutes.
Class 3, Division 1.				
Nitroglycerine extracted from dynamite, etc.	160	71·1	2 c.c.	15
Carbonite, Monobel and similar explosives from which the nitroglycerine cannot conveniently be extracted by water	160	71·1	3·2 g.	7
Blasting gelatine, gelatine dynamite and analogous preparations	160	71·1	3·2 g. +6·5 g. French chalk	10
Cordite,* ballistite and other propellants of Class 3, Division 1	160	71·1	3·2 g.	10
Class 3, Division 2.				
Nitrocellulose pulp, compressed guncotton, tonite and analogous compressed nitrocellulose preparations	170	76·7	1·3 g.	10
Nitrocellulose propellants . . .	170	76·7	1·3 g.	10
Ammonite, bellite, roburite, and analogous preparations	170	76·7	1·3 g.	10
* For the acceptance of New Cordite and Cordite MD for the British Naval and Military Services the details are as follows :—				
Cordite and Cordite MD	180	82·2	1·6 g.	30

Mechanism of the Abel Heat Test. The test depends upon the liberation of iodine from the potassium iodide by nitric peroxide. The quantity of nitric peroxide necessary to colour the paper to the standard tint is very small. Robertson and Smart found it to be 0·000135 mg.

The relation between the time of the test and the concentration of nitric peroxide was also studied by Robertson and Smart. A lag of about four minutes occurs at the start, due to the time of heating of the explosive. In some cases, however, the action on the test paper is not due wholly to decomposition during the test, but is in part due to nitric peroxide dissolved in the explosive.

The test has been frequently criticised on account of the minute quantity of nitric peroxide which is measured. This necessitates exact adherence to standard conditions of working in regard to the design of apparatus, preparation of the test-papers, etc. The exact end point is somewhat difficult to determine, and is liable to be affected by the illumination, notwithstanding the use of a standard tint for comparison.

In some cases the traces of decomposition measured may be due to relatively harmless impurities. The test may also be shortened by traces of oxidising substances, such as organic peroxides which liberate iodine from potassium iodide ; on the other hand, the test may be masked by certain substances such as mercury.

The quantity of moisture present (in gun-cotton, for instance) may affect the results ; if moisture condenses on the sides of the tube, nitric peroxide is absorbed. If, on the other hand, the test-paper becomes too dry, the sensitiveness is decreased.

According to Köhler and Marqueyrol calcium carbonate does not affect the test directly, but in presence of water it gives rise to hydrolysis of nitrocellulose and forms traces of calcium nitrite, which lower the test. If, however, the conditions be closely adhered to, it serves a useful purpose, especially in the manufacture of nitric esters. It is also very simple to apply.

Attempts were made at an early date to overcome the masking of the test by the use of other indicators in place of potassium iodide and starch. The zinc iodide test is, of course, open to the same criticisms.

(b) Zinc Iodide Test

This is a German modification of the heat test. Zinc iodide is used in place of potassium iodide. This renders the test rather more sensitive.

(c) Guttmann's Test

Guttmann used a solution of diphenylamine in sulphuric acid as indicator to overcome the masking effect of mercuric chloride, etc., on the Abel test. Jannopoulos described a modification in which the finely ground powder is previously warmed to 35-38° for four days before testing. The tests are inapplicable to nitroglycerine powders, as the nitroglycerine vapour is decomposed by the sulphuric acid.

(d) Hoitsema's Test

Diphenylamine was also used in this test, but was applied on glass wool instead of paper.

(e) Spica's Test

In this test a solution of metaphenylenediamine hydrochloride was used. This is unduly sensitive and the indicator has poor keeping properties.

Various other reagents, such as indol, sulphanilic acid and alpha-naphthylamine, dimethylaniline, beta-naphtholsulphonic acid, etc., have also been tried as indicators.

(f) Hess Test

In this test the explosive was heated at 70° in a current of air, which was passed into a solution of zinc iodide and starch. The time taken to impart a blue colour to the solution was noted.

(g) Vieille Test

In this test the decomposition is carried considerably further. Ten g. of the explosive is weighed into a glass tube, and a strip of litmus paper is placed in the upper part of the tube. The tube is corked and placed in a water-jacketed oven, the jacket being maintained at 110°. The actual temperature of the explosive is approximately 108·5°. If the litmus turns colour within ten hours, the tube is at once removed; otherwise the tube is removed after ten hours. In either case the explosive is exposed to the air overnight, and on the following day it is reheated similarly with a fresh strip of litmus. This is repeated every day until the colour-change occurs within an hour. The total number of hours of heating is then taken as a measure of the stability. The following limits are given by A. P. Sy. For large powders thirty hours; for small powders twenty hours; for ungelatinised nitrocellulose ten hours.

(h) Horn-Seifert Test

In the original test of Horn, 2 g. of powder was heated in a long test tube at 120°, and nitric peroxide was observed by looking down the length of the tube. A disc of white porcelain was laid on the surface of the powder to facilitate the observation. Seifert modified the test by introducing a test-paper (methyl-violet and rosaniline) and observing the successive changes of colour.

(i) Continuous Stability Test

The case in which the explosive was stored was fitted with a narrow metal tube communicating with a glass tube containing a porous material impregnated with litmus or other indicator. The gases evolved by the explosive on storage reacted with the indicator.

(j) Methyl Violet Test

Methyl violet is gradually turned blue green, and ultimately a pale salmon colour by nitric peroxide. It is much less sensitive than starch iodide. For the test, 2·5 g. of the dried sample of explosive is placed in a glass tube 29 cm. long and 1·5 cm. internal diameter. The sample is pressed down to occupy a depth of 5 cm. and a methyl violet paper is placed in the tube with its lower edge 2·5 cm. above the explosive. The tube is inserted in a bath at 134° to 135° so that about 6 to 7 mm. of the tube projects from the bath. After twenty minutes the tube is partially withdrawn to examine the paper, and this is repeated at intervals of five minutes until the paper becomes salmon-pink. The time of the test should be at least thirty minutes. The papers are prepared by dipping Schleicher and Schüll's filter paper No. 597 in a solution of pure rosaniline acetate (prepared from 0·25 g. basic rosaniline), 0·168 g. methyl violet (crystal violet), 4 c.c. glycerine, 30 c.c. water, made up to 100 c.c. with pure 95 per cent. alcohol. The dried paper is cut into strips 2×7 cm.

(k) Pollard's Test

This depends upon the action of nitric peroxide on colloidal silver oxide. A current of air is passed over the powder and into a colloidal solution of silver oxide. The nitric peroxide reacts with the silver oxide and decreases the amount of light diffused by the colloid. The decrease forms a measure of the decomposition of the nitric esters.

(l) Jensen's Test

Nitrocellulose powder is heated gradually from 100° upwards as in the deflagration test. A strip of iodide paper is suspended over the powder and the temperature at which the test-paper gives a coloration is taken as an indication of the stability of the powder.

II. STABILITY TESTS DEPENDING ON THE DIRECT OBSERVATION OF BROWN FUMES

(a) Simon Thomas Test (1898)

The explosive is heated at 100° for eight hours each day until visible fumes appear. The test has subsequently been used in Holland in a slightly altered form. A quantity (usually 2½ g.) of explosive is heated to 95°, first for four hours in an unstoppered flask, and then for eight-hourly periods. In general nitrocellulose requires fourteen to twenty-four daily periods. The test is stated to give good results for ungelatinised nitrocellulose, but to be less satisfactory for propellants.

(b) American Test at 65·5° or 80°

A hard glass-stoppered bottle of 8 oz. capacity is filled to one-third with the propellant and maintained at 65·5° or 80° until brown fumes appear. The time of the test ranges up to 300-400 days at 65·5° or 75-100 days at 80°. As the powder deteriorates, the time of the test decreases until ultimately tests of one to six days are obtained.

(c) International 75° Test

Two samples of 10 g. each are placed in capsules 35 mm. diameter and 50 mm. in height; the capsules are loosely covered with watch glasses, and are heated for forty-eight hours at 75°. The appearance and odour of the powder and the formation of nitrous fumes are noted. If there is any positive indication of decomposition the explosive is considered to be of unsatisfactory stability.

(d) Warmlagermethode 75°

This test is largely used in Germany for nitrocellulose and propellants. Five g. of the explosive is heated in stoppered tubes of 200 mm. length and 28 mm. diameter at 75°. The tubes are left open for sixteen hours and are then stoppered, and the heating is continued without interruption until distinct brown fumes appear. They are opened once a week for ten minutes to renew the supply of oxygen necessary to convert NO to NO_2. The test is stated to give reliable results and to give good concordance in tests done on the same powder at different times. A temperature of 100° is sometimes used.

III. STABILITY TESTS DEPENDING ON SPONTANEOUS HEATING OF THE EXPLOSIVE

(a) Silvered Vessel Test

This test was devised by Robertson for the testing of cordite. The apparatus consists of a vacuum-jacketed flask, which is maintained at 80° in a bath. The cordite is ground as for the heat-test, and 50 g. is placed in the flask. A thermometer is fitted in the neck of the flask with its bulb in the ground cordite. The neck of the flask has a lateral side-tube for the observation of brown fumes of nitric peroxide. The test is continued until the thermometer shows a rise of 2° due to spontaneous heating of the cordite. The time is then noted, and taken as a measure of the stability. The test usually requires several hundred hours, but the time varies greatly with the nature of the powder.

(b) Taylor's Test

In this test 4·5 g. of nitrocellulose is heated in a tube 30 cm. long and 1·4 cm. in diameter at 135°. A thermometer is fixed with its bulb embedded in the nitrocellulose, and the heating is continued until a rise of temperature is indicated. This usually requires forty-five to sixty minutes.

IV. TESTS IN WHICH DECOMPOSITION IS CARRIED TO EXPLOSION

(a) German 132° Test

This test has been used to a considerable extent in Germany for the testing of nitrocellulose and powders. The nitrocellulose is dried and heated in a glass tube. Observations are made of the change of colour of litmus paper, the formation of brown fumes and the explosion of the samples. The test was formerly carried out at 135°, but is now carried out at 132° and the observations are frequently confined to the brown fumes. For the test as formerly carried out the following limits were given by Sy.

	Litmus.	Fumes.	Explosion.
Ungelatinised nitrocellulose	30 mins.	45 mins.	5 hrs.
Nitrocellulose powder	75 ,,	120 ,,	5 ,,
Nitroglycerine powder	30 ,,	45 ,,	5 ,,

In the test as now carried out, 2·5 g. of the sample of nitrocellulose or smokeless powder is placed in a tube 350 mm. long, 16 mm. internal diameter, and 19 mm. outer diameter. A strip of blue litmus is pushed down so that it is 25 mm. above the explosive. The glass tube is loosely closed with a cork disc or a paraffined cork, and put into a bath containing boiling xylene, with a reflux condenser. The cover of the bath is provided with orifices to hold the tubes. The orifices are 11 cm. deep and contain glycerine.

Uniformity of the litmus is of great importance.

(b) Deflagration Test

A bath of mineral jelly is heated to 100°. Test tubes, each containing 0·1 g. of explosive, are suspended in the bath, and the temperature is then raised at the rate of 5° per minute. Little paper caps are lightly fixed on the mouths of the tubes to indicate which sample has exploded. The temperatures of explosion are noted. Berl and Rueff described an apparatus consisting of a copper block, heated electrically, with holes for the test tubes.

A combination of the deflagration test with the Abel test is given by Jensen.

(c) Time to Explosion

In some cases the explosive is maintained at constant temperature, and the time to explosion is measured. Patterson gives a number of results, of which the following is an example :—

Temperature	136°	139·5°	143°	148°	160°	168°
Time to explosion	5 hrs.	2 hrs.	1 hr.	30 m.	16 m.	12 m.

Weber describes an apparatus in which the powder is heated in glass tubes at 160°, 170°, 180° and 200° and the time to explosion is measured.

V. Quantitative Determination of Nitric Peroxide

Bergmann and Junk Test

This test is widely used for the testing of nitrocellulose. The apparatus is shown in Fig. 6. The heating tube consists of a glass tube, 35 cm. long and 19 mm. in diameter. The ground glass neck is fitted with an absorption vessel containing water. The nitrocellulose is well dried and 2 g. is placed in the tube, which is then heated in a bath of special construction. The bath is maintained at 132° by a boiling liquid. After two hours' heating the tube is removed from the bath, and water is poured into the cup. As the tube cools, the water is drawn into the main tube. The cup is rinsed out with water into the main tube, the volume being made up to 50 c.c. The tube is well shaken and the contents filtered. A little permanganate is added to oxidise nitrous acid, and the nitrogen is estimated by the Schulze-Tiemann method. Titration with alkali has also been used to determine the nitrous and nitric acid, but in this case allowance must be made for the calcium carbonate in the nitrocellulose.

The test has generally been found very reliable. Sometimes rapid decomposition sets in and the test has to be discontinued ; occasionally explosions occur. For this reason a modified test has been devised by V. Meerscheidt-Hüllessem in which the reaction tube can be rapidly cooled without removing it from the bath.

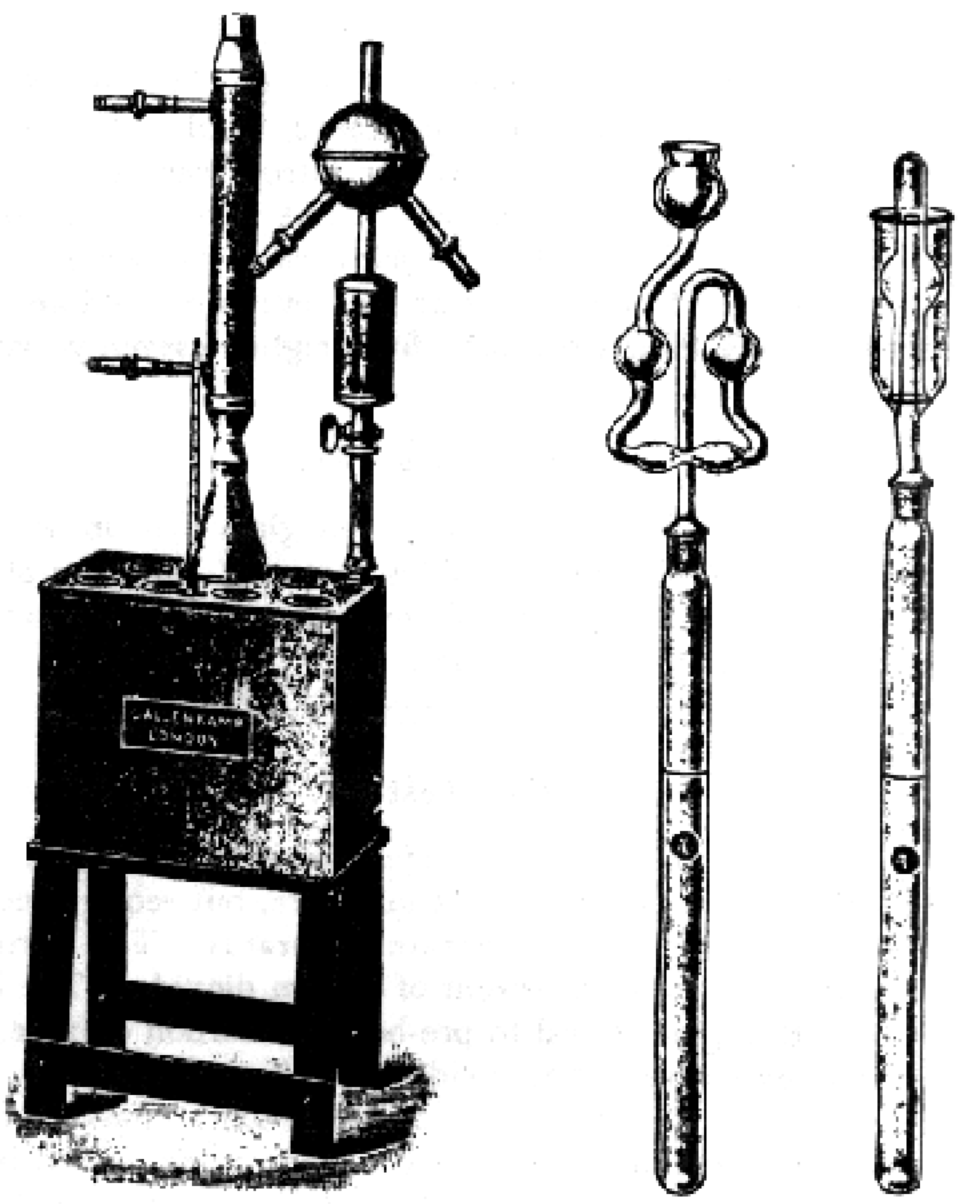

Fig. 6.

A modification of the test is described by Mayrhofer. In this the nitric peroxide is collected in potassium iodide solution, which is then titrated with thiosulphate. A special feature of the modified method is the addition of 0·05 to 0·25 c.c. of water to the 2 g. of explosive, to facilitate hydrolysis of the esters. Comparative tests are carried out under the wet and dry conditions. The method is stated to be applicable to nitroglycerine powders.

The Bergmann and Junk test is applied to nitrocellulose powders in Germany. Five g. of powder is taken for the test, and parallel tests are made on a control powder. A good nitrocellulose powder with stabiliser is stated to give 5 to 8 c.c. of nitric oxide after five hours' heating.

VI. Loss of Weight due to Decomposition

(a) Method of Sy

The unground powder is heated at 115° on an open dish for eight hours daily for six days. The daily loss of weight is determined. Limits are given for nitrocellulose powders of different thicknesses. The test has been criticised on the ground that the volatile catalysts do not exert their due influence, and further, that different powders in the same oven may affect one another.

(b) Method of Meerscheidt-Hüllessem

In this test 10 g. of the unground powder is heated in a glass tube to retain the volatile catalysts. The tubes are 200 mm. long and 30 mm. in diameter and are maintained for eight hours each day at 115° in a bath capable of holding a large number of tubes. The samples are weighed every day up to about ten days.

(c) Dutch Test

Thomas's original test (p. 80) has been gradually developed, and has taken the form of a " Loss of Weight " test. In this form it has received considerable attention in Holland for smokeless powders.

The apparatus consists of a glass tube 160 mm. long and 18 mm. internal diameter, with a glass stopper. Four g. of the powder, finely ground and passed through a 0·5 mm. sieve, is placed in the tube, which is then heated at 104° to 106° for nitroglycerine powders and 109° to 111° for nitrocellulose powders. The tube remains open for the first eight hours, but is closed during each subsequent heating. The sample is weighed every morning and evening. Stable powders should not lose more than 2 per cent. from eight to seventy-two hours.

(d) Brunswig's Test

Five g. of powder is heated in an open glass dish in an oven of special construction fitted with a revolving stand. The loss of weight is determined, first after three days' continuous heating at 110°, and then after daily periods of eight hours.

VII. Gasometric Stability Tests

(a) Will Test

This is used as a rule only for ungelatinised nitro-cotton. It is a valuable test for the control of the manufacture, but requires considerable attention and somewhat elaborate apparatus. The nitro-cotton (2·5 g.) is heated at 135° in a current of carbon dioxide. The heating tube is fitted with a glass spiral to pre-heat the carbon dioxide, before it reaches the explosive. The oxides of nitrogen evolved by the explosive are carried forward by the carbon dioxide, passing through a copper U-tube containing copper and copper oxide, which is maintained at a red heat. All oxides of nitrogen are thus reduced to nitrogen, whilst carbon monoxide and hydrogen are converted to carbon dioxide and water. The gases are then led into a gas-measuring tube filled with potassium hydroxide solution. This absorbs the carbon dioxide, and leaves the nitrogen, which is measured at intervals of fifteen minutes for four hours. The heating tubes are enclosed in a metal case with strong glass windows, as explosions occur occasionally. A good nitro-cotton gives a uniform evolution of gas, whilst unstable nitro-cottons give an irregular and increased evolution. Purity of the carbon dioxide is of importance.

A modification of the test has been described by Goujon in which the heating tube is enlarged to hold 10 g. of nitro-cotton.
The quantity of nitrocellulose is reduced to 0·3–0·5 g. An electrically heated copper block is used in place of a liquid bath.

As all volatile substances are driven off by the current of gas, the Will test measures essentially the decomposition due to non-volatile catalysts such as traces of sulphuric acid.

(b) Dupré's Vacuum Test

One g. of the ground dried powder is placed in the test tube. The top of the tube ends in a flat ground surface, and the joint is made between this and a similar flat surface of the connecting tube by means of luting composition. A similar joint is made to the manometer which consists of a syphon barometer. The bath is kept at a constant temperature, *e.g.* 125°, by boiling water under increased pressure. The evacuated tube is placed in an orifice in the bath. After half an hour the tube is re-evacuated and the test started five minutes later. Readings of the manometer are then taken every half-hour for about four hours. The tubes can be re-evacuated if necessary.

(c) Mittasch's Method

The chief feature of this test is that the rise in pressure of the gases is registered automatically. This necessitates more complicated apparatus, and the practical application of the test has been very limited.

(d) Obermuller's Method

In this test the explosive is heated in a vacuum, and the gas evolved is measured by means of a mercury manometer. Various forms of the test have been described. In one of these 1 to 2 g. of nitrocotton are placed in a tube of 12 c.c. capacity which is heated at 135° or 140°. A small glass rod rests on the nitrocotton to prevent it from being ejected upwards on application of the vacuum. Useful results have been obtained for ungelatinised nitrocotton, but the test appears to be unreliable for gelatinised powders after storage. This is probably due to the continuous removal of the volatile catalysts.

(e) Brame's Method

This also depends on the measurement of the rise of pressure in an evacuated tube containing the explosive, by means of a mercury manometer.

(f) Chiaraviglio and Corbino

These authors describe a method in which a very sensitive manometer is used to measure the rate of decomposition at relatively low temperatures.

(g) Taliani's Test

This test has a device which prevents the volatile products from reaching the cool parts of the apparatus, thus ensuring that the catalysts are kept in contact with the explosive, and also preventing the distillation of nitroglycerine, when this forms a constituent of the explosive. The apparatus is shown in Fig. 7. The tube A containing 1·3 g. of the explosive is fitted with a tap C, and connected with a tube which has a double bend B. The U-shaped part of this tube is partly filled with heavy paraffin. This part of the apparatus is entirely enclosed in the hot bath. The tube B is further joined by a rubber connection to a glass tube leading to the manometer F. One limb of the manometer is divided into two tubes, one of which is fitted with a tap as shown. The paraffin trap prevents the volatile products from entering the manometer.

The test is usually carried out at 120° with nitroglycerine powders and 135° with nitrocellulose. The tap C and the manometer tap remain open until equilibrium has been obtained in the whole apparatus and any moisture has evaporated. When the taps are closed, any gases evolved from the explosive exert a pressure on the paraffin. By raising the mercury reservoir, the paraffin can be

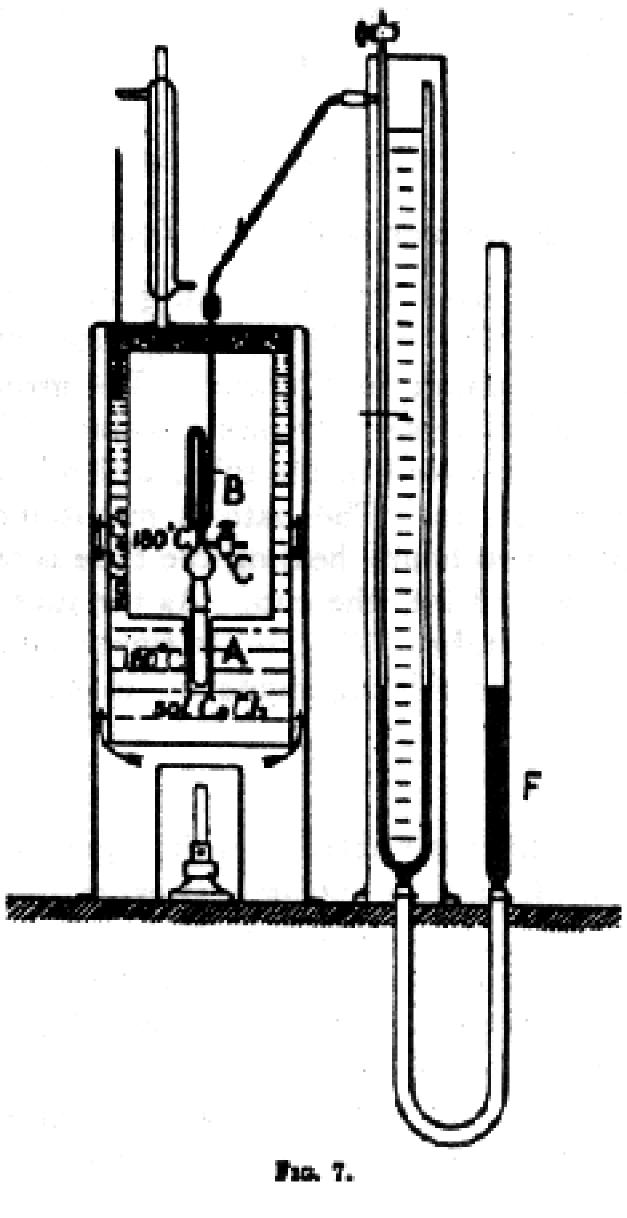

Fig. 7.

brought to the same level in the two limbs. The pressure is then read off on the scale. Readings are taken every five minutes until the difference of pressure reaches 100 mm. or 300 mm. Good drying of the explosive is necessary, as the results are affected by moisture. Calcium carbonate also has a marked effect.

(h) V. Meerscheidt-Hüllessem's Test

One of the main features of the test of Taliani described above is that the volatile products are not allowed to escape. This can also be effected by enclosing the powder in a vessel containing liquid paraffin with a syphon tube arranged so that the gases evolved displace the liquid and cause it to overflow into a beaker which can be periodically weighed. The test is carried out at 120° with measurements every fifteen or thirty minutes. The method is simple, but very few results have been published so far.

(i) Desmaroux Test

A copper bath is filled with glycerine and maintained at constant temperature by a regulator. It is double walled to conserve the heat and has a number of orifices to receive the glass heating tubes. These are 3 cm. in diameter and 10 cm. high. Each tube has a ground glass stopper with a capillary outlet leading to a mercury manometer. Ten g. of explosive is placed in the tube, which is then evacuated. The tests are carried out at 75° and 108·5° and the rate of decomposition is measured by the rise of pressure in the manometer.

(j) Marqueyrol's Test

The explosive is heated at 50° in a vacuum, and the slow evolution of gas is measured by means of a manometer. Readings are taken every three or four days over a long period.

VIII. MEASUREMENTS OF ACIDITY

One of the primary causes of instability of nitrocellulose and gelatinised explosives is the presence of traces of acidity, or of unstable esters which readily break down, yielding acids. Since esters are hydrolysed by moisture in presence of acids, the decomposition is autocatalytic, and the presence of acid is thus of great importance.

(a) Angeli's Test

This is designed primarily for gelatinised powders. The powder is ground or cut into very thin flakes and 0·5 g. placed in a test tube. A small quantity of distilled water is added, and then 3 or 4 drops of a 0·2 per cent. alcoholic solution of dimethylaminoazobenzene. The whole is well mixed and either warmed for a few moments in boiling water or allowed to stand in the cold. The solid powder takes up the indicator and becomes more or less red according to its degree of acidity.

(b) Tomonari's Test

This test is applied to ungelatinised nitrocellulose. It depends on the solubility of acidic impurities of the nitrocellulose in methyl alcohol. One g. of the nitrocellulose is boiled for fifteen minutes with methyl alcohol and the solution is titrated with 0·01 *N* sodium hydroxide solution, using methyl red as indicator. The titre is called the acid number (x), and $100/x$ is called the *stability number*. The explosion temperature falls with a rise in the value of x. When x is less than 5 the cellulose nitrate is considered stable.

(c) Measurement of *p*H Value

This method depends upon extraction with water and measurement of the acidity either by indicator solutions or by the quinhydrone electrode.

It is necessary to use pure water, as used for electric conductivity work, and to adhere to constant conditions of working. The method is frequently combined with a heating trial. Thus Hansen heated smokeless powders in the ground condition at 110° and tested samples at intervals of an hour by means of the quinhydrone electrode to ascertain the rate of formation of acid. In a modified method the powder is heated under water at 100° to bring about a hydrolytic decomposition. Grottanelli passes a slow current of air over a large sample (500 g.) of powder, which is maintained at 80°, and then into an absorption vessel in which the *p*H value is measured. Pavlik also passes the gases into water under modified conditions. The effect of calcium carbonate in powders has been examined by Metz.

(d) Conductivity Method

De Bruin and de Pauw have described a method depending on the electrolytic conductivity of an aqueous extract of the explosive. A number of flasks, each containing a weighed quantity of dried nitrocellulose or powder, are first heated to drive off residual moisture. The contents of one of the flasks are treated with 150 c.c. of "conductivity water," well shaken, and allowed to stand. The flask is again shaken, the liquid is filtered, and its conductivity measured. The other flasks are heated at constant temperature (100° to 132°) for known periods and the conductivity is similarly determined. The conductivity increases with the duration of the heating, and this increase is taken as a measure of the stability.

IX. STABILITY OF HIGH EXPLOSIVES

The aromatic nitro-compounds, which form the basis of most of the high explosives used for Service purposes, do not as a rule respond readily to such tests as the Abel heat test. In general these compounds undergo very little deterioration on storage, but in some cases it is necessary to test them. The most reliable results of definite value in the comparison of high explosives are obtained by vacuum stability tests.

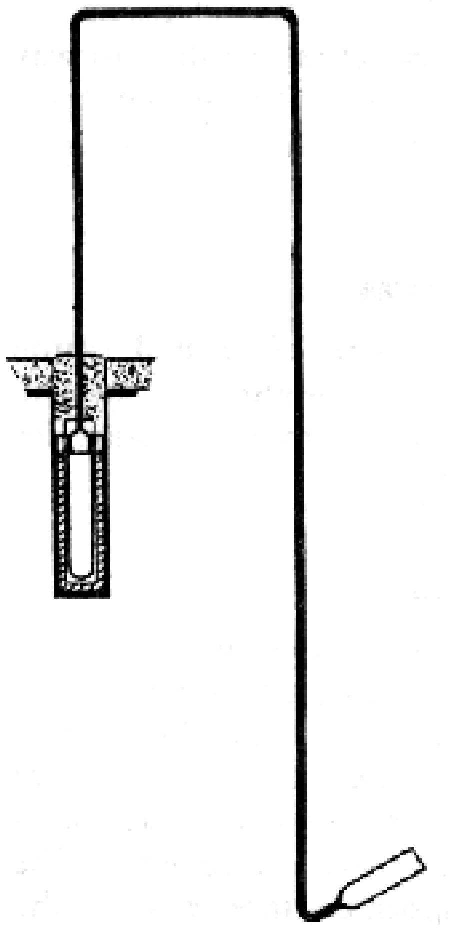

FIG. 8.

Vacuum Stability Test

The explosive is dried and weighed out into a test tube of the pattern shown in Fig. 8. The manometer is attached and the tube evacuated and placed in a thermostat of special design. The temperature of the test varies from 80° to 180° according to the explosive under test. The progress of the decomposition is followed by readings of the mercury manometer.

Method of Haid, Becker and Dittmar

The apparatus consists of a glass vessel connected with a manometer. The explosive is dried over phosphorus pentoxide, and 42 g. introduced through a side-tube which is then sealed off. The manometer is in the form of a U-tube and contains mercury covered with a layer of paraffin. The glass vessel is also fitted with a side-tap. It is heated in a bath to 75° and completely sealed. The evolution of gas is then measured by means of the manometer.

Acidity Measurements

The method of *p*H determination is applied as in VIII (*c*) above (p. 91). Five g. of explosive is heated at temperatures ranging from 75° to 132° according to the nature of the explosive, and the gradual fall of *p*H is measured by periodic tests.

Loss of Weight

In Germany, industrial blasting explosives are exposed to a temperature of 75°. Ten g. is heated in a loosely covered weighing bottle, 30 mm. diameter and 50 mm. high, and the loss of weight is determined periodically.

MATCHES AND FIREWORKS

A. MATCHES

I. NATURE OF MATERIAL FOR MATCH-STEMS

1. Woods

WHITE or soft pines of Canadian origin are largely used in the manufacture of matches. The pine tree grows to a height of 100 ft. or more, and is 7 ft. or more in diameter. For the manufacture of matches the young pine, on account of its very soft texture, is to be preferred. It is essential to have the wood dry and thoroughly seasoned, thereby reducing the water content and improving its physical properties by rendering it less brittle. The wood should be stored in well-ventilated sheds and protected from the sun and rain.

In addition to pine, fir and spruce, the following woods are used, especially in countries to which these are indigenous, viz.: aspen, poplar, lime, beech and willow, and to a more limited extent, alder-wood. Aspen wood, which comes mainly from Russia, is very easy to flake and gives splints of uniform size. The strips of wood for match boxes are also made from the aspen tree and on the same machine. It is probable that for match splints aspen wood will supplant pine wood in this country.

Fir woods closely resemble the pines in being needleleaf or soft woods but have no resin ducts. The variety mostly favoured is the white or silver fir.

Spruce woods resemble the soft pines. They grow extensively in North America and Europe. The common varieties are the Norway spruce (*Picea excelsa*) and the Douglas spruce or fir (*Pseudotsuga douglasii*). The Norway spruce resembles silver fir but the resin ducts are visible though few in number.

2. Wax Matches or Vestas

The stems of wax matches consists of a wick of twisted cotton threads, coated with wax, or more generally with mixtures of stearin, paraffin, and gum dammar or gum opal. These matches burn for a longer time than matches made from wood.

3. Cardboard Matches

Within recent years safety-matches with stiff paper or cardboard stems have become very popular, and numerous patents have been taken out for the manufacture of such matches, *e.g.* B.P. 288620/1927 and B.P. 332700/1929. These are usually made up in the form of a book, and generally consist of two rows of ten matches each in a cover. These matches are made automatically by machinery. The cardboard is slit and dipped, and the composition then put on the cover. The machine also binds and cuts the books apart. Matches are also produced in disc form and in the form of a cylinder. When a match is withdrawn from the latter bundle it is ignited by friction. Various details of paper matches are described in U.S.P. 2,022,088 (1936). Hand dipping in batches still survives to some extent in cardboard match manufacture.

II. SUBSTANCES USED TO IMPREGNATE THE SPLINTS

The match sticks are either square or round, according to whether they are made by flaking or planing. The grooved splints, sometimes employed, are punched by upward cutting dies from small wooden blocks fed into the machine in a special way. The round splints are compressed, and have a closer texture than the square sticks, and are better suited for sulphur-coated match manufacture. The sulphur which coats the lighting end does not enter the pores, so that a loose structure is unnecessary. With the majority of other dipping substances it is preferable to have a porous foundation, as the substances tend to penetrate the wood. Sulphur is now scarcely ever used. Paraffin and other waxes are generally employed to impregnate the splints. In addition resin and other fatty acids such as stearic are commonly employed. These will be considered individually. To prevent the after-glow of the splints, and the falling-off of the glowing ember, the splints are dipped into a solution of phosphoric acid and ammonium nitrate, or other fire-proofing materials, such as alum or boric acid. Hygroscopic substances should be avoided.

A solution of celluloid in amyl acetate may be used in place of gum, etc., as binder in order to render the match damp-proof. The stems and heads may be dipped in a similar solution. A moisture-proof match-ignition composition containing cellulose derivatives has also been suggested in other patents (*e.g.* 355901/1930).

1. Paraffin and Other Waxes

Waxes, which are usually the fatty esters of the monohydric alcohols, find a limited application in the match industry. Paraffin wax, a hydrocarbon, is the most important in this connection. It is the highest boiling fraction of the products of distillation of paraffin and lignite. It is sold in different grades according to its melting point, which may range from 35° to 60° C. For the manufacture of matches the more or less yellow and brown, soft, scaly variety is the most important. Paraffin waxes with a melting point of 98° to 102° F. (Scotch method), 101° to 105° F. (American method), and 38° to 39° C. (German method) are the most favoured.

The determination of the melting point of wax may be carried out as follows: 0·5 g. is weighed approximately (first time, afterwards judged by size) and wedged at the top of a hook of platinum wire (0·025 in. diam.) fused on to the end of a glass rod, which passes through a hole in the cork fitted into a dry test-tube. The cork also carries a thermometer with its bulb near the platinum hook. The test tube is slowly heated in water and the melting point noted. Alternatively, the wax may be melted in a small beaker, slowly stirred with a thermometer, until the temperature becomes steady for a short period, with solidification of the mass. For more accurate determination a large bath is employed and the liquid mechanically stirred. When the melting point is not sharp and for petroleum jellies the apparatus of Ubbelohde may be employed. A small quantity of the jelly is pressed into a small glass perforated cup which fits on to the bulb of the thermometer. On slowly heating, the temperature at which the drops of liquefied paraffin fall away from the cup is noted. The English method of determining the setting point of paraffin wax consists in filling a test tube (1 in. diam.) to a depth of 2 in. with molten paraffin and inserting a small accurate thermometer. The tube is then allowed to cool and the temperature at which the thermometer remains stationary for a short period is regarded as the setting point.

Shukoff's apparatus for determining the titer test of fatty acids consists of a tube 3 cm. diam. surrounded by a Dewar vacuum mantle, the outer diameter of which is 5 cm. and the height 10 cm. The molten paraffin is poured into the inner tube, which is closed by a cork fitted with an accurate thermometer. The vessel is slowly cooled with shaking and the point at which without further shaking the thermometer remains steady and then rises is noted. The highest point is taken as the setting point.

Considerable uncertainty still exists as to the manner in which the English, Scotch, American and German methods of examination are carried out. The German and American methods are in close agreement when Fahrenheit degrees are converted into Centigrade degrees by the well-known formula $C^\circ = (F^\circ - 32) \times \frac{5}{9}$; whereas after converting the English or Scotch degrees by the same formula, it is always necessary to add on 2° C. Ignorance of this difference in the methods is often taken advantage of by dealers, as paraffin wax is sold according to melting point, and the German test gives higher results.

The wax commonly used when first obtained is yellow; if melted and poured into cold water, it forms thin strips which are bleached white by the action of the air. In this country, wax for the manufacture of wax matches has been partly or entirely replaced by stearin with or without paraffin wax. Cotton threads or bobbins are passed through a ring so as to form one single thread, which is then passed through a trough containing the molten wax mixture. This thread is then passed through a wire-drawing plate which gives it an exactly cylindrical shape and a smooth surface. The wax mixture used usually contains about 10 to 15 per cent. of paraffin wax. Wax matches for tropical countries contain a small amount of Carnauba wax. The latter is a hard vegetable wax which raises the melting point and increases the hardness of the wax, thus preventing the matches from sticking together.

In impregnating the splints with paraffin wax the molten paraffin is heated to such a point that a match stick "boils" when plunged into it. As the vapour of paraffin wax is unpleasant, it is desirable to fit an efficient air draught to the paraffin bath.

2. Stearin (Stearic Acid)

Stearic acid, incorrectly called stearin, is one of the higher fatty acids. It is a waxy, crystalline solid, which melts at 69·2°. It is made on an industrial scale from animal and vegetable fats. These are hydrolysed by means of superheated steam alone or with addition of a small percentage of calcium hydroxide. The calcium salt produced is changed into stearic acid by the addition of the requisite amount of sulphuric acid.

Stearin was used, at one time, with the addition of a little resin, in the preparation of the wood for matches "de luxe." In the manufacture of matches it is unnecessary to use the hardest and whitest sorts of stearin, as the softer kinds have been found to give even better results. Stearin has been replaced by paraffin for making wood matches, but it is still used, with gum opal or dammar, for wax match stems. In the match industry the only test required is to determine the melting point of the stearin before use. In this connection the Shukoff method for determining the melting point of paraffin wax (*cf.* p. 96) is used.

3. Resin

The dried resin of the coniferae is used in match compositions, or for mixing with the stearin; Venice turpentine is the best. Addition of resin causes the flame to smoke strongly. The addition of insoluble synthetic resins as binding material is claimed to give a match-head unaffected by water.

4. Sulphur

For occurrence, examination for purity, etc., see Vol. I., pp. 358 *et seq.*

Sulphur melts at 114·5° C. to a clear yellow liquid, which, on further heating to above 125° C., becomes darker and very viscid; at 400° C. it is again yellow and mobile and begins to volatilise. During cooling these phenomena reappear in inverse order. If the sulphur becomes thick, it is too hot, and must be cooled further before the splints can be dipped.

For the manufacture of matches very pure sulphur is not needed. The small amount adhering to the splint always appears pure and is inflammable. Finely powdered roll-sulphur is preferred to flowers of sulphur for the manufacture of safety-match compositions.

Differences between Powdered Sulphur and Flowers of Sulphur under the Microscope. The powdered sulphur consists of more or less transparent crystals, while flowers of sulphur consist of dark, cauliflower-shaped masses. In polarised light, between crossed nicols, flowers of sulphur are devoid of optical activity, while the crystalline particles of the powdered sulphur appear light on a dark ground. Sulphur is scarcely ever used as a coating for match splints in this country, although it is an essential ingredient of some match compositions, especially those used for safety-matches.

III. MATERIALS FOR MATCH COMPOSITIONS

A. COMBUSTIBLE SUBSTANCES

1. **Ordinary or Yellow Phosphorus.** — Phosphorus is usually prepared from bones or naturally occurring phosphorite, in both of which it is present as tricalcium phosphate. At ordinary temperatures yellow phosphorus is a crystalline solid having a sp. gr. of 1·83 at 10°. Above 15° it becomes soft and waxy, melting at 44·4° to a yellow liquid. It is readily soluble in carbon disulphide, chloroform, benzene and sulphur chloride (S_2Cl_2), and almost insoluble in alcohol and water. Friction, or warming to 60°, in the air causes phosphorus to burn with a bright, yellowish white flame, to phosphorus pentoxide, P_2O_5. Yellow phosphorus is a deadly poison, as little as 0·1 to 0·2 g. causing death; inhalation of the "fume" causes "phossy jaw," or necrosis of the jaw-bone, a disease prevalent amongst workers in the match factories. Fortunately, its use in most countries is now prohibited by law.

Examination of Commercial Yellow Phosphorus. The impurities present in yellow phosphorus are traceable to the sulphuric acid used in its manufacture. The principal adulterants are sulphur, arsenic and iron. To test for sulphur, a fragment of the phosphorus is dissolved in dilute nitric acid, and the solution, which now contains the phosphorus as phosphoric acid, is tested with a solution of barium nitrate; a white precipitate, insoluble in nitric acid, indicates the presence of sulphur in the phosphorus. Another portion of the solution is diluted, nearly neutralised with alkali, and treated with sulphuretted hydrogen; any arsenic originally present exists as arsenic acid in the nitric acid solution. The latter with hydrogen sulphide gives a yellow precipitate of arsenious sulphide. If iron is present, a precipitate of Prussian blue is obtained, on the addition of a few drops of potassium ferrocyanide solution to the nitric acid solution.

2. **Dark Red Phosphorus,** a second allotropic form of phosphorus, is manufactured on the large scale by heating the yellow variety in sealed iron cylinders for a few minutes at 250° to 300°. Red phosphorus differs considerably in properties from the yellow form. It is non-poisonous, is unaffected by the air and is insoluble in carbon disulphide. Moreover, it is odourless. It has a sp. gr. of 2·106. When heated in air it does not ignite until a temperature of 200° is reached. Generally it is less chemically active than yellow phosphorus.

Red phosphorus is used chiefly for the preparation of the striking surfaces on safety-match boxes and is also occasionally employed in the manufacture of "strike anywhere" match compositions. While pure red phosphorus is non-poisonous, the commercial product can act as a poison, as it frequently contains traces of the white modification. Fresenius and Luck analysed a sample of commercial red amorphous phosphorus with the following results:—

Red phosphorus	92·630 per cent.
White phosphorus	0·560 ,,
Phosphorous acid	1·302 ,,
Phosphoric acid	0·880 ,,
Water and impurities	4·662 ,,

Although the presence of a small amount of white phosphorus is not in itself detrimental in match-making, it has been assumed to be the cause of a slow oxidation to phosphorous and phosphoric acids, which on account of their acid and hygroscopic properties, act on the other substances present. This supposition is, however, unnecessary, for red phosphorus, which has been carefully purified, becomes oxidised after long contact with air, and contains under these circumstances considerable quantities of phosphorous acids. Factories do not generally trouble about any special examination or purification, although in 1909 it was proposed to use "neutral amorphous phosphorus" obtained from the ordinary product by purification methods. The phosphorous acids are estimated quantitatively by extracting a weighed quantity (10 g.) on a filter with warm water, until the filtrate no longer reacts acid. A definite portion of the filtrate is now oxidised by repeated evaporation with nitric acid, and the total phosphoric acid then precipitated with magnesia mixture. The phosphorous acid is estimated with mercuric chloride in another portion of the filtrate. To estimate the percentages of white and red phosphorus present, Fresenius and Luck (*loc. cit.*) oxidise the phosphorus, after washing free from acids with warm water, with fuming nitric acid to phosphoric acid, and estimate the amount of phosphorus in this as magnesium ammonium phosphate. The quantity of red phosphorus is similarly estimated in another portion of the sample, after extracting the yellow variety with carbon bisulphide. The difference between these two quantities gives the amount of white phosphorus present.

The German official method, worked out by Siemens, is as follows:—Three g. of phosphorus is dried, and boiled for half an hour on a steam-bath, under a reflux condenser, with 150 c.c. of benzene, and filtered. One c.c. of this solution is added to 1 c.c. of a solution of ammoniacal silver nitrate, made up by dissolving 1·7 g. of silver nitrate in 100 c.c. of ammonia of sp. gr. 0·922. If, after shaking and allowing to stand, no change or only a yellow coloration of the aqueous solution takes place, white phosphorus is absent. But if the aqueous solution is coloured red or brown or contains a black or brownish-black precipitate, white phosphorus is present. The colour of the aqueous solution should be judged directly after shaking and allowing to stand, and not after prolonged standing.

3. **Light Red Amorphous Phosphorus**, sometimes called scarlet phosphorus, is another allotropic form. It is prepared by dissolving yellow phosphorus in phosphorus tribromide and boiling the solution. The new modification separates out of the solution as a finely divided, amorphous powder. Like dark red phosphorus, the scarlet form is not poisonous. It is, however, more chemically reactive than the former owing to its more finely divided condition. Conversion of scarlet into dark red phosphorus may be brought about by continued heating at 300° in a current of carbon dioxide. Schenck determines the phosphorus by heating a weighed quantity with water, together with bromine contained in a small tube, in a sealed tube, for two or three hours in a steam-bath at 100°; the oxidised phosphorus is weighed as magnesium pyrophosphate.

Scarlet phosphorus is used in compositions for parlour matches, *i.e.* matches requiring no special ignition surface.

4. **Phosphorus Sesquisulphide (P_4S_3).**—This compound is formed by slowly heating the calculated quantities of phosphorus and sulphur in a current of carbon dioxide at 330°; a small excess of sulphur is used. By sublimation at 260°, regular crystals are obtained, but on crystallisation from carbon disulphide, rhombic prisms melting at 166° and boiling at 380° are obtained. Phosphorus sesquisulphide is soluble in carbon disulphide, phosphorus trichloride and in aqueous solutions of sodium and potassium sulphides. Alkalis readily decompose it. The commercial product ignites in air at 98° to 99°. Cold water has no appreciable action on phosphorus sesquisulphide, but boiling water decomposes it into sulphuretted hydrogen and phosphorous acid. The commercial product sometimes contains free phosphorus, the presence of which is detected by passing a current of hydrogen over the sulphide when, if phosphorus is present, the issuing gas will burn with a green flame. The pure product keeps well in stoppered bottles, but the commercial product gradually decomposes with evolution of sulphuretted hydrogen.

Phosphorus sesquisulphide was officially introduced into France by Sevène and Cahen for the manufacture of "strike anywhere" matches, free from white phosphorus. It is now used in the manufacture of matches almost to the exclusion of yellow phosphorus.

The examination of phosphorus sesquisulphide is carried out first, by the smell (odour of phosphorus) and then by Mitscherlich's test (*cf.* detection of phosphorus in match-heads, p. 134), or by the method of Schenck and Scharff. These methods are exact and permit the detection of very small traces.

5. **Lead Thiosulphate ($Pb\ S_2O_3$)** is now used for the preparation of match compositions, which ignite on any surface. It is prepared by treating a solution of "sugar of lead" (lead acetate) with sodium thiosulphate; it is a pure white, inodorous, tasteless powder, insoluble in water and not hygroscopic. It should be kept in well-closed bottles. Twelve kg. of lead acetate yield, when treated with 5 kg. of sodium thiosulphate, about 9·5 kg. of lead thiosulphate. A pure sample should contain no water-soluble matter.

6. **Antimony Trisulphide (Sb_2S_3)** is used to some extent for match compositions, but principally in the preparation of the striking surface of safety-match boxes. It can be obtained in a purity of 99 per cent. Tests for purity are not necessary.

7. **Other Substances.**—A few other substances have been recommended for match compositions, such as persulphocyanic acid, ferrocyanogen compounds, potassium xanthate, thiocyanates, "sulphocuprobarium polythionate" and "thiophosphit." Thiophosphites made by heating such sulphides as antimony and zinc sulphides with red phosphorus and sulphur in an atmosphere of carbon dioxide to a temperature of 450° C. are used in match compositions patented by the Elektron Fabrik. Matches of this composition are less affected by moisture than those containing phosphorus sulphides. The addition of an ignition mass containing an inorganic non-combustible binding substance has been suggested for repeat ignitable matches.

B. SUBSTANCES WHICH SUPPLY OXYGEN

1. **Minium or Red Lead (Pb_3O_4)** is prepared by heating yellow lead oxide (massicot) in air to about 300°, when it absorbs oxygen and becomes converted into red lead. It has a sp. gr. of about 8·8. As the use of minium is solely dependent on its oxygen content, only the purest product should be used (with not more than 1 per cent. of impurity). This is tested by dissolving 1 g. in a mixture of 2·5 g. of nitric acid (sp. gr. 1·15), 3 to 4 g. of water and 0·5 g. of oxalic acid and filtering.

2. **Lead Peroxide mixed with Lead Nitrate.**—This "mixture" is prepared by treating minium with nitric acid of sp. gr. 1·384. A moderate amount of heat is evolved. Minium, whose composition may be written $2PbO\ .\ PbO_2$, gives up the lead oxide (PbO) to the nitric acid to form lead nitrate, the peroxide remaining unchanged. Excess of nitric acid is to be avoided, as it not only acts on the binding substance in the match composition, but also renders the phosphorus inactive, by oxidising it to phosphoric acid. It also gives the mixture a thin consistency, whereas if the correct quantity of acid is used, the product is stiff and pasty. A badly made mixture contains too much lead nitrate, which causes the match-head to sweat, thereby producing a bad ignition and giving an unsightly appearance to the match-head. The product must also be free from lead chlorides and lead sulphate, which are avoided by using pure raw materials.

3. **Lead Peroxide** is prepared from red lead, by boiling it, in fine powder, with dilute nitric acid, washing and drying. It has a sp. gr. of 9·4. It readily parts with oxygen to other substances and hence is used in match compositions. The percentage of lead peroxide in a sample can be estimated by treating the peroxide with a measured volume of hydrogen peroxide previously acidified with nitric acid. The following reaction takes place:—

$$H_2O_2+PbO_2+2HNO_3 = Pb(NO_3)_2+2H_2O+O_2.$$

The undecomposed hydrogen peroxide is then determined by titration with potassium permanganate solution.

4. **Lead Nitrate** is readily obtained in match factories by allowing the wash-waters, obtained in the preparation of lead peroxide, to crystallise.

5. **Manganese Dioxide**—

The value of the dioxide depends on the amount of available oxygen. Manganese dioxide is seldom used for phosphorus compositions, but is employed for safety and non-poisonous "strike anywhere" match pastes, and also on the striking surfaces.

6. **Potassium Chlorate.**—

It is the most powerful oxidising agent used in the match industry, and the substitution of the very hygroscopic sodium chlorate for it is not to be recommended.

7. **Potassium Nitrate.**—

It is essential that refined saltpetre only be used, as the crude salt contains chlorides which are deliquescent.

8. **Potassium Dichromate.**— It is used in the manufacture of safety-matches, and in very small quantities in the compositions of red phosphorus matches.

9. **Barium Nitrate, Strontium Nitrate.**—These substances are used principally in pyrotechny (see p. 149).

10. **Calcium Orthoplumbate (Ca_2PbO_4)** is a heavy yellowish-red powder prepared by heating calcium oxide and litharge to redness in air. It was first prepared by Kassner and was recommended as a substitute for lead peroxide and lead nitrate, in the manufacture of non-poisonous "strike anywhere" phosphorus matches. Schwiening's composition is used by match-makers, owing to the prohibition of the use of white phosphorus, and contains calcium orthoplumbate, together with potassium chlorate, amorphous phosphorus, friction material, binding and colouring substances. The calcium plumbate appears to act as a negative catalyst on the explosive mixture of potassium chlorate and phosphorus, retarding the explosion, so that only inflammation occurs.

C. SUBSTANCES WHICH INCREASE FRICTION, INERT SUBSTANCES, OR FILLING MATERIALS

Among these substances are powdered glass, pumice stone, sand, chalk, plaster of Paris, pulverised asbestos, siliceous marl, Kieselguhr, powdered quartz, brown umber, Venetian red, zinc oxide and pulverised paper moulded with a binder, *e.g.* rubber solution or starch.

These serve, on the one hand, to increase the friction, and on the other to retard the explosion on igniting the match-head, so that the flame has time to act on the other materials, sulphur, paraffin, etc., which propagate the combustion. Brown umber is a variety of clay coloured by the oxides of iron and manganese. Venetian red is ferric oxide, Fe_2O_3, and is obtained by the calcination of green vitriol. The use of chalk as a filling material is now rare. Zinc oxide is employed chiefly in the compositions of matches containing phosphorus sesquisulphide, red phosphorus and the like.

The above substances can all be obtained in the requisite degree of purity.

D. BINDING SUBSTANCES

1. Glue

I. The Composition and Manufacture of Glue

Boiling water extracts from certain portions of vertebrate animals a material known as glue. These portions are the connective tissues and the intercellular substance of the sinews, ligaments, bones and dentine. A genuine glue contains mainly the complex nitrogenous organic substance gelatin. A number of other substances are often called glues: for example, starch glues, casein glue, marine glue, and various mineral and vegetable adhesives. The nature of glue is to some extent determined by the class of tissue from which it is made. The various tissues from which glue is obtained can be briefly classified as follows: ossein in bones and skin, chondrigen of cartilage and isinglass from the bladders of fish. These three classes are included under the general heading of *Collagens*. *Chitinin*, $C_{18}H_{30}N_2O_{12}$, is the main constituent of the shells of lobsters, beetles, crabs, etc. It is a white translucent substance, but has very poor properties as a binding material. *Keratin* is from horns, hair, nails, feathers, wool, etc., and remains after these materials have been treated with chemicals and solvents. These again are poor adhesives. *Sericin*, $C_{15}H_{25}N_5O_8$, is extracted from silk by boiling water under pressure. It resembles gelatin but is precipitated by lead acetate. *Elastin* is obtained from certain ligaments.

For commercial glues the tissues classified as the collagens supply the only practical raw material. The glues from this source may be classified as follows:—

1. *Glutin* is the main constituent of commercial glue; it has the approximate composition:—

Carbon	50·0	per cent.
Hydrogen	6·6	,,
Nitrogen	17·8	,,
Sulphur	0·25	,,
Oxygen (by diff.)	25·2	,,
Ash	0·2	,,

It swells up in water without dissolving. On heating it changes to a liquid and on cooling again gelatinises. It is soluble in acids and alkalis at laboratory temperature. On continued boiling with water, glutin loses its solidifying property (*i.e.* its property of gelatinising on cooling). It is not precipitated by acetic acid, potassium ferrocyanide or nitric acid, and in this way differs from the true albuminoids. Most varieties of tannic acid throw it out of solution.

2. *Chondrin* is somewhat similar to glutin, but is more horny in structure and its adhesive power is less. It is obtained by boiling cartilage with water; the resulting opalescent liquid gelatinises on cooling. It can be precipitated by dilute mineral acids but redissolves in excess. It is sometimes regarded as a mixture of glutin with mucin. Mucin is generally regarded as a mixture of complex organic substances which are generally removed during the liming process. They have practically no adhesive properties, and if present in glutin to any appreciable extent they give rise to foaming when the solution is warmed.

Commercial gelatin glues are divided into various classes, according to the raw products from which they are made, as follows:—

Skin Glue. For the manufacture of this glue, waste materials from the slaughter house are used. The inner skins contain a large amount of connective tissue which, on extraction with boiling water, yields glue. The first process consists of a treatment with lime or sodium sulphate in open, shallow pits for several days, with repeated agitation. The insoluble material is then washed and scraped to remove hairs and flesh. The cleaned material is next boiled with water in open vessels and the resulting solution (which contains the glue) is filtered and concentrated *in vacuo* at approximately 60°. The resulting dark viscous solution is decolorised by charcoal and sulphur dioxide and the hot filtered solution allowed to settle.

Leather scrap may also be utilised for glue manufacture by digestion with an aqueous solution containing 5 per cent. of sodium hydroxide on the weight of the dry leather scrap. The mixture is boiled until the glue-like substances are liberated, drained and filtered. The solution is then decolorised, if necessary, and concentrated. A clear glue can also be obtained by agitation with porous vegetable material of open texture, possessing approximately the same cellular structure as that of the material from which the glue is made. Kieselguhr may also be added and the filtered decolorised solution further concentrated.

Bone Glue. This type of adhesive is obtained from bones of various types. The fat is first removed by a restricted steaming in a digester or by solvent naphtha or petroleum. To extract the glue the bones are heated under pressure with steam in special autoclaves. The calcium phosphate may be first removed by acids and the residue steam treated. The solution after clarification is concentrated *in vacuo*.

Fish Glue. Various types of fish offal are used and the treatment is somewhat similar. Glues of this type are generally deodorised to some extent by the use of sodium phosphate or otherwise.

The addition of potassium dichromate to the glue is stated to make the match composition gradually damp-proof owing to the oxidation of the glue.

A water-soluble albumin has also been proposed as an ingredient in the mixture for match-heads and striking surfaces. The binding agent containing a soluble albumin is rendered insoluble in water during drying of the composition.

II. PROPERTIES AND EXAMINATION OF GLUE

Glue is mainly used for its adhesive and binding properties. A good glue should be very hard and not readily brittle. When struck with a light hammer it should give a loud, sharp sound. It should be clear and transparent with a pale colour, with freedom from foreign particles. This latter property may give rise to mistakes, as the so-called benzine glues, although thin and pale-coloured, are, as a rule, inferior to true gelatins. When placed in cold water it should only swell and take up a large volume of water without dissolving; the water should have at most only a faint odour and should not show any appreciable cloudiness. On heating to 50° good skin glue should completely dissolve. Numerous methods are in use to test the quality of glue. Lipowitz estimates the bearing power of a gelatinised glue solution of definite concentration (generally 10 per cent.) at a definite temperature. The glue is placed in cylinders which are closed with a lid through which, in a guide tube, passes a stout wire, to the lower end of which is fixed a convex disc. On the other end is fixed a balance pan. The convex surface rests on the top of the jelly and weights are added until the lower disc penetrates. The greater the weight added, the greater the consistency.

Liquid Glue can be obtained by treating 100 parts of glue with 140 parts of water and 16 parts of nitric acid; it still retains the adhesive power of the glue used in its production, but does not gelatinise. This glue, and also liquid glue made with acetic acid, will not serve for the manufacture of match compositions.

Water Resistant Glue. The addition of formaldehyde polymerides or related compounds to animal glues produces a water resistant glue.

Examination. A weighed quantity of dry glue is allowed to remain for twenty-four hours in cold water, then allowed to dry and weighed again. The nearer the final weight approaches to the original, the better is the sample.

The desirable properties in a glue vary with the purpose for which it is to be used; the buyer often lays chief stress upon the binding power of the glue. As the determination of the binding power is difficult, Kissling devised the following simplified scheme for testing glue.

1. Kissling's Scheme for Testing Glue

1. *Determination of Moisture.* A sample is removed from the slab of glue with the aid of a coarse wood rasp, 2 to 3 g., quickly weighed out on to a large watch-glass, and dried to constant weight in an air-oven at 110° to 115°. It is absolutely necessary to carry out the drying with finely powdered glue, for the moisture cannot be completely expelled at the above temperature from larger particles, and it is advisable to resort to a higher temperature. The moisture content of a good glue is generally between 10 to 20 per cent. A lower result indicates that the glue has been overheated in drying and the adhesive properties may be affected. Powdered glue loses very perceptibly in weight, if allowed to stand in the laboratory at the ordinary temperature for some time.

2. *Determination of Ash.* For the determination of the ash it is convenient to use the same sample of glue as was taken for the moisture determination. It is incinerated in a covered platinum or silica crucible, the full heat of a Bunsen burner being at once applied. The traces of mineral matter which are lost in this shortened method may be neglected without danger, since only great differences in the quantity of ash need be taken into account. The last particles of carbon, which are somewhat difficult to remove, are best burnt by repeatedly allowing to cool, moistening, and igniting the contents of the crucible.

3. *Qualitative Examination of the Ash.* The nature of the ash generally gives reliable indications as to whether the glue was derived from bone or from hide. The ash of bone glue melts at the temperature of the Bunsen burner, its aqueous solution generally reacts neutral, and its solution in nitric acid gives the reactions for phosphoric and hydrochloric acids. If the ash has been very strongly ignited, deposits of alkali chlorides are found on the inside of the crucible cover and sometimes on the edge of the crucible. The ash of skin or hide glue contains a large proportion of lime and remains therefore unmelted. It reacts strongly alkaline and is generally free from phosphates and chlorides. An unadulterated glue should have an ash content of approximately 2·5 per cent. or less.

4. *Determination of Alkalinity.* To 2 g. of glue, dissolved in 18 g. of water, is added 40 g. of 99 per cent. alcohol; after brisk agitation, the mixture is filtered and titrated with *N*/10 hydrochloric acid, phenolphthalein being employed as the indicator.

5. *Free Mineral Acid* is determined by titrating a 10 per cent. solution of the glue in water with aqueous sodium hydroxide solution, successive portions of the liquid being spotted on to neutral litmus paper. The quantity of alkali to be added each time before the spotting must correspond to 0·005 g. H_2SO_4. During the titration, the glue solutions are warmed to about 30°. Phenolphthalein may be used as indicator.

6. *Determination of the free and combined volatile Acids.* Thirty g. of the glue is covered with 80 g. of water in a round-bottomed flask and placed aside for a few hours to allow the glue to swell. An arrangement is then fitted up which permits of the removal of the volatile acids by steam distillation, the flask being conveniently placed in a vessel containing boiling water, in order to avoid the condensation of any considerable quantity of steam. As soon as the distillate no longer has an acid reaction, the distillation is stopped, and the quantity of acid is determined by titration. To liberate the combined volatile acids, the contents of the flask are next acidified with concentrated sulphuric acid, and distilled again in a similar manner. In some instances the distillate contains considerable quantities of sulphurous acid, so that it is advisable to distil into a known quantity of standard alkali. The sulphurous acid can be converted into sulphuric acid by the addition of bromine, and then determined gravimetrically. The acid content of a good glue is generally less than 0·2 per cent.

7. *Determination of the Drying Properties.* The solution of glue, freed from volatile acids, is diluted with water to a weight of 150 g. and again heated to the temperature of boiling water with an upright tube to prevent loss by evaporation. Ten c.c. is then withdrawn by a pipette on to the middle of a watch-glass of about 10 cm. diameter, in such a way that no glue is present on the glass outside the circular disc of jelly, the centre of which must coincide with that of the glass. The watch-glass is placed in a horizontal position before the addition of the glue; it should be allowed to remain in a place as free as possible from dust and draughts, and where the temperature is not liable to fluctuate greatly. The alterations of the glue are then observed for a few days. According to the drying properties of the glue, the jelly dries more or less quickly from the edge to the centre, and from the size of the patch which still remains soft after a certain time, a fairly reliable conclusion can be drawn as to the drying properties of the sample. As the process

of drying is greatly influenced by the degree of moisture and temperature of the air, and as it is very difficult to keep these constant, it is advisable always to carry out comparative determinations. It is, therefore, advantageous to compare the glue under examination with two samples which have been previously tested, one of good, and the other of inferior drying properties, the three being treated identically, as above.

8. *Determination of Foreign Matter.* Kissling recommends only an approximate quantitative determination of the total quantity of those substances which are deposited when the glue solution is sufficiently diluted. The separation of these substances by filtration is troublesome and slow, even after partial separation by decantation, so Kissling makes approximate determinations of the volume of the solid deposit, since the estimation is only comparative. The glue solution referred to in (7)—that is to say, 150 c.c. less 10 c.c.—is diluted with hot water, allowed to cool, introduced into a cylinder of 1000 c.c. capacity, graduated in c.c., filled up to the mark, mixed and allowed to stand. The volume of the solid deposit, after twenty-four hours, forms a measure of the quantity of insoluble " foreign matter " in the glue. This is generally very small, but in some cases considerable. Such substances decrease the binding quality of the glue when they consist to a great extent of organic matter.

9. *The Odour.* This feature is of especial importance, as it gives indications concerning the durability of glue, and its tendency to decompose. The smell of glue varies greatly according to the quality. Usually, hide glues are in this respect superior to bone glue. With some kinds of glue, the smell of the cold slabs is very slight, whereas the hot jellies have a very unpleasant smell. In such cases the glued surface, after drying, has a much more unpleasant smell than the cold slab. In his published results, Kissling therefore gives indications of the smell, both of the dry glue and of the hot jelly. Obviously, it is only possible to judge the odour accurately after carrying out a long series of investigations of glues.

In general a satisfactory agreement has been found between the results of practical experience and those of Kissling's tests. The amount of acidity determines the suitability of a glue for some purposes. The quantitative estimations of water, ash and fat (see p. 111) are generally of minor importance. Hide glues show a superiority over bone glues, but it must be emphasised that the manufacture of bone glue has undergone such improvements that its relative value in comparison with hide glue has greatly increased. The best bone glues now compare approximately with medium skin glues.

In a subsequent publication, Kissling emphasises the fact that all forms of apparatus devised for the purpose of directly measuring the binding power, the first requirement in the testing of glues, fail to give even approximately concordant results under identical conditions of experiment. This is, at all events, his experience with apparatus devised by himself for this purpose (*loc. cit.*), and for this reason he prefers the determination of the drying properties of glue. In a later paper he strongly advocates, and describes an apparatus for, ascertaining the melting point of the glue jellies.

The main conclusions from a paper by E. G. Clayton, on the technical examination of glue, based on investigations of a number of samples of British and foreign origin, are as follow :—Colour is of limited value as an indication of quality, and too much importance is often attached to it. Some dark-tinted glues may be better in quality than comparatively pale samples. Air bubbles should be few, or better, absent. The odour of samples should be inoffensive. Good glue should not deteriorate quickly on exposure. Physical tests usually lead to more definite conclusions than analyses, but some of the chemical data are very useful. Perhaps the best *single* chemical test is Stelling's—the determination of non-gelatinising matters by precipitating with alcohol, filtering, evaporating a fractional part of the filtrate, and weighing the dried residue. A high result appears to be a *primâ facie* indication that the glue, at all events, is below the best standard of quality. Hygrometric, immersion, jelly-drying, viscosity, and other tests are described in the paper. The viscosity test and Kissling's jelly-consistency test are favourably reviewed, and the hygrometric test (rate of absorption of moisture from air saturated with aqueous vapour) is stated to give useful indications. Finally, it is remarked that whilst it would be rash to form a judgment on glue from a single test, the evidence afforded by a number of tests may be decisive.

The hydrogen ion concentration of a glue may often be an important determination as giving an opinion of the value of such product, according to Bogue. If the pH value is 4·7 the viscosity will be low and the product nearly insoluble. On either side of this point the properties change considerably, attaining their maximum on the acid side at pH 3·5 and on the alkaline side at pH 9·0. The measurements may be made by electrometric or colorimetric methods.

2. Methods for the Determination of Fat in Glue

W. Fahrion recommends the following process :—Ten g. of broken glue is warmed on a gently boiling water-bath with 40 c.c. of 8 per cent. alcoholic sodium hydroxide in a porcelain dish, with constant stirring, until the alcohol is completely driven off. If complete solution does not occur, the residue is taken up with alcohol and again evaporated to dryness. The transformation product of the glutin, as also the sodium salts of the fatty and hydroxy-fatty acids dissolve readily ; any residue which is found, consists of inorganic matter, and dissolves on subsequent acidification with hydrochloric acid. The acidified solution is heated for about half an hour almost to boiling, then washed into a separating funnel, and after cooling, well shaken with ether and allowed to stand for a considerable time, best over night. The acid aqueous liquid is drawn off, and the ethereal solution which contains the fatty acids and the liquid hydroxy-fatty acids is poured off at the top. The solid hydroxy-acids which remain behind in the funnel are dissolved in warm alcohol, the ethereal and alcoholic solutions combined and evaporated, the residue weighed, ignited, and again weighed and the difference taken as the fat. The results obtained in this way agree satisfactorily among themselves, but are always too low, for two reasons. Firstly, any glycerin present in the glue fat is not determined with the fat, and secondly, the hydroxy-acids are not quite insoluble in acidified water. The error which results in this way is, however, very small, For instance, the quantity found for a brown joiner's glue by Kissling's method was 0·21 per cent., by Fahrion's method, 0·51 per cent., and in an almost white skin glue, by Kissling's method, 0·13, and by Fahrion's method, 0·40 per cent. of fat.

According to Kissling's method (shaking out the glue solution, with petroleum ether after acidification with hydrochloric acid), only that part of the fat which is soluble in petroleum ether, is determined. The fat contained in glue is, however, partly oxidised, and oxidised fats are in some cases insoluble in petroleum ether. The raw materials for the manufacture of glue, namely, skin and bones, already contain oxidised fat. Further, the glue decoction is repeatedly heated in presence of air, and finally the drying of the glue brings it into such intimate contact with the air that the oxidation of the fat probably proceeds further. Indeed, Fahrion found in a skin glue only 0·08 per cent. of fatty acids as compared with 0·31 per cent. of oxidised fatty acids.

3. Differentiation of Animal and Vegetable Glue

F. Evers has published an investigation on the differentiation of animal and vegetable glue. The distinction between animal glue and dextrin glue, or between gum and mixtures of gum or dextrin with animal glue, is based upon the well-known reaction towards Fehling's solution, which is reduced in presence of dextrin on boiling. So-called plant glue (albumin glue, gum), which is prepared from wheat gluten and is used for gumming and cloth dressing, is very similar to animal glue in its physical and chemical properties, particularly to inferior bone glue. Its aqueous solution gives, like animal glue, a voluminous gelatinous or cheesy coagulum with tannin solution; with a little aluminium sulphate solution it gives no precipitate, or at the most only a slight separation, but with larger quantities of aluminium sulphate it yields a greater amount of a flocculent or cheesy precipitate, whilst with lead acetate it undergoes no change. In general, vegetable glue swells and dissolves with more difficulty in water than animal glue, and the solution gelatinises less readily on cooling. A trustworthy method for distinguishing between the two cannot, however, be based upon this property. Both animal and vegetable glue give flocculent precipitates with concentrated sodium sulphate, which, however, redissolve on warming. If the solution be boiled for some time and treated with lead acetate, animal glue gives a white or pale grey precipitate, while vegetable glue, containing as it does, larger quantities of sulphur, generally gives a black precipitate, less frequently a grey one. An aqueous solution of vegetable glue gives on warming with Millon's reagent a violet-red coloration, like all albuminoid substances; in many cases, however, inferior animal glue behaves in the same way.

A simple and trustworthy method for distinguishing between animal and vegetable glue is the following:—The sample of glue (about 1 g.) is dissolved in water (10 c.c.) by warming, a drop of sodium hydroxide solution being added if necessary. A few grams of common salt or magnesium sulphate are then added, and the whole shaken. The solution of animal glue remains clear, whilst vegetable glue separates almost completely as a voluminous or gelatinous precipitate. Mixtures of animal and vegetable glue can be readily recognised in this way.

4. Physical Tests

The physical examination of glue, especially viscosity, rate of drying, gelatinisation point, joint strength, elasticity, etc., are important and are often determining factors in judging the value of a glue.

(*a*) **Viscosity.** — According to the investigations of Fels, the consistency of glue is closely related to the quality or binding power. Neither the quantity of water taken up, nor the examination of the mode of fracture gives trustworthy indications of the practical value of a glue, but the viscosity of the solution is a better index of quality. The reason of this is evident; glues which have been prepared under the influence of lime or acids give rise, under certain conditions, to a less consistent jelly than a properly manufactured product, namely, when the lime or acid has not been sufficiently carefully removed from the glue. The decomposition products which result in presence of lime or acids, especially on boiling or steaming the glue-producing substance, as also those which result when too high a steam pressure has been used, diminish the consistency of the jelly, as does also a badly regulated concentration of the glue solution, or even an incipient organic decomposition of this solution.

All these influences affect the finished product, and if the degree of consistency of the jelly obtained from a glue be examined, a true measure for adjudging the quality is obtained. The method is very simply carried out as follows:—

1. *Determination of Moisture.* The sample is broken up, 1 to 2 g. of powdered glue obtained from the fragments, with the help of a file, rasp, or knife, and this quantity is dried for two hours at 100°.

2. *Preparation of the Test Jelly.* About 100 g. of the glue under examination (viz. the broken pieces from which the fine powder was filed) is placed in a beaker of 500 c.c. capacity, and about 400 c.c. of cold water added; after twenty-four hours the swollen glue is dissolved by heating on a water-bath. The dilution is carried out in such a way that a 15 per cent. jelly results, calculated on the anhydrous glue.

Clark and Du Bois describe a physical test for glues. It consists in determining the weakest solution of the glue which gives a solid jelly at 10°. If a 6 per cent. solution of the substance is liquid and a 7 per cent. solution is solid, the jelly is said to have a comparative jelly value of 7 per cent. The comparative strengths of glue jellies can be found by determining the ease with which swollen particles of glue melt and slide when placed on a sloped brass plate. The lower end of the plate is dipped into water and kept at 40°. The better glues retain their grip on the plate for the longer period.

3. *Determination of the Viscosity.* Engler's viscosimeter is especially good for this purpose. First, the viscosity of water at 30° is determined, and used as a unit for the subsequent glue tests. The same determination is then carried out with the 15 per cent. solution of glue, also at 30°. The time of flow of the latter divided by that of water gives a number which expresses the consistency of the glue.

Some results obtained by this method of examination are given in the following table. Sample No. 2 was quite slimy after a few hours and sank together to a lump, whereas No. 5 preserved its original form and gave up no particles of jelly, even when scraped with the finger. Further, it was found that Nos. 3 and 5 became a solid jelly after twelve hours, whereas No. 2 was still a thin jelly, and underwent no alteration even after a further period of twenty-four hours:—

Description of sample.	Substance used, in grams.	Moisture content per cent.	Corresponding quantity of anhydrous substance.	Dissolved to c.c.	Time of outflow of 500 c.c. in seconds.	Viscosity.
1. Light yellow, transparent thick slabs .	95·0	16·3	79·6	530	Time of outflow of water at 30° = 90 seconds. 149	1·65
2. Brown glues, transparent	95·0	14·0	81·7	544	125	1·38
3. Wine yellow, transparent slabs . .	88·7	15·4	75·1	500	171	1·90
4. Light yellow slabs, breaking into small pieces	100·0	18·2	81·8	545	150	1·66
5. Semi-opaque glue .	100·0	15·2	84·8	565	199	2·21

In the MacMichael viscosimeter a plunger of standard size is used, suspended by a torsion wire above the instrument. The glue is placed in a cup which is rotated at a constant speed on a motor-driven platform. The viscosity determines the twist on the wire which is measured by a disc attached to the spindle.

The viscosity of gelatin and glue is affected by the acidity of the material, by the age of the solution, and by other factors. A method of testing glues suggested by Lenk consists in measuring the time of gelatinisation in minutes at pH 7·0—7·5. He proposes the formula $y = -0{\cdot}55\,x + 1{\cdot}8$, where x = log. of gelatinisation figure in minutes and y=viscosity.

Goebel determines the viscosity of hide and leather glues in 17 per cent. solution at 40°, and of bone glue at 30°. He uses either an Engler or Vogel-Ossay instrument and determines the concentration by means of a Suhr glue hydrometer calibrated in percentages.

(*b*) **Melting Point of the Glue Jelly.**—Kissling considers that such chemical methods as precipitation with tannin, or estimations of the percentage of nitrogen, are unsuitable for adjudging the value of a glue.

A bath of copper or other metal partially filled with water at 50° serves as the source of heat. The bath should be filled to a mark placed at two-thirds of its height, and the temperature is kept constant during the experiment. The bath is fitted with a removable cover consisting of a vessel, the bottom of which is covered with a sheet of asbestos upon which rests a ring-shaped receiver. In this a thermometer and the small cylinders containing the glues are placed. The upper vessel is covered with a glass plate. It is advisable to cover the outside of the vessel with asbestos. The method of working is as follows:—Fifteen g. of the glue samples to be tested and 30 g. of distilled water are introduced into small flasks, each fitted with a straight tube about 1 metre long. The flasks are allowed to stand over night and then heated in boiling water until the glue has dissolved completely, solution being accelerated by shaking the flasks with a circular motion. The flasks containing the lukewarm glue solutions are then fitted into the glass cylinders, which are made exactly to a specified size and are provided with ring-shaped marks; the cylinders are closed with corks and placed in a holder, the base of which consists of a brass sieve, over which two intermediate discs are fixed, each containing seven holes. The cylinder containing the thermometer is placed in the middle, and contains a concentrated solution (1 : 1) of the best hide glue. The receiver thus filled is allowed to stand for an hour in water, the temperature of which is kept at 15°. After the thermometer vessel and test cylinders have been thus brought to the same temperature, they are quickly brought into the thermostat, which has been

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fitted up as above, and the melting point of the glue jelly determined. The melting point is the temperature at which the horizontal surface of the jelly begins to become uneven. The higher the melting point, the higher is the content of gelatinising substance. In addition, this simple method gives direct indications as to the degree of firmness of the glue jelly, which is of importance in certain cases, as, for instance, in glueing casks.

As regards the testing of plates of glue, the question whether a glue is good or bad, useful or useless, cannot be answered in a general way unless it is so inferior in quality that it can be discarded at once as worthless. In the great majority of instances the purpose for which it is to be used must be known; hence a glue can only be designated as unsuitable for a specific purpose.

So far as the binding properties are concerned, numerous experiments have shown that even inferior bone glues are satisfactory, and hide glue of high quality scarcely shows any superiority in this respect. If, therefore, only the binding properties have to be taken into consideration, there is no object in using the more expensive hide glues. This does not hold good for the degree of firmness. Experiment has shown that hide glues are in general superior to bone glues in this respect, although some samples of the latter yield moderately firm jellies. As is well known, the method of manufacture plays an important part in reference to this property; the larger the quantity of glutin that is converted to glutose during the manufacture, the less firmness does the jelly possess, and in this respect the manufacture of bone glue has undergone great improvements.

Considerable weight is attached by some writers to the "Foam-test." Foam is due to over-boiling, which causes peptonisation. A good glue, it is stated, should yield a minimum foam, when the solution is shaken, coupled with a maximum jelly consistency.

(*c*) **The Binding Power.**— *Setterberg's Method.* This author soaks strips of unglued paper in a glue solution of known concentration, removes the excess of glue by pressing between blotting paper, and when dry, estimates the binding power of the glue by subjecting the strips to tearing tests in a paper-testing machine.

2. The adhesive power of glue can be determined by the method of Rudeloff. A standard aqueous solution of the glue is applied to two wooden surfaces of definite areas. The surfaces are previously cleaned and dried at 40°. Two wooden glued surfaces are placed in contact, and the films allowed to make contact at a pressure greater

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than 0·84 kgm. per sq. cm. The force required to separate the glued surfaces after a definite time is then measured.

3. ***Weidenbusch's test for Binding Power.*** This test gives reliable results. Exactly equal prismatic rods of plaster of paris, 9·2 cm. long, with the side of the transverse section 4 mm., and having a weight of 1·7 g., are dipped in a glue solution for five minutes, then taken out, and allowed to dry. They are then placed on an iron ring, which is fastened in a horizontal position, so as to form the diameter; a dish is hung to the centre of the rod, into which weights are placed until the rod breaks. The better the glue, the greater the weight required to break the rod. By experiment it has been found that the relative adhesive power of skin glue to that of bone glue, is as 1·5 : 1; and, further, that glue made from calves' head is better than any other class of glue. The following table bears out these facts :—

Class of glue.	Breaking strain.	Appearance of fracture.
	Grams.	
Glue from crushed bones, Saybusch .	291·6	Even, four-sided.
Russian glue from Bohemia . . .	304·2	Even, fine-grained.
Saybusch glue, Lyon class . . .	351·2	Slightly uneven.
Russian glue from A. Michl, Rehberg .	434·2	Uneven, with sharp projecting edges.
Cologne glue from A. Michl, Rehberg .	434·2	Do.
Glue from calves' heads, from Saybusch, Lyon class	463·7	Do.
Plaster of paris rod before dipping in glue	103·2	Fairly even, fine grained.

Evaluation of a Glue from Viscosity Tests. The chemical analysis of a glue generally does not greatly help in its evaluation. The examination of moisture, ash and water adsorption give some information regarding the nature of the glue, but other tests are necessary, particularly those of a physical nature. The jelly consistency at low temperature or the viscosity at high temperature give useful comparative figures. Bogue recommends the measure of the viscosity of an 18 per cent. solution at 35° by means of the MacMichael viscosimeter as an indirect test for the differentiation of glues and gelatins. It is recommended as a basis for the primary evaluation of these products. Tests of jelly consistency and viscosity at 60° are recommended for secondary evaluation.

For the rapid determination of the quantity of glue or gelatin in dilute liquors for the control of manufacturing processes physical methods are essential. Measurements of refractive index have been found very suitable.

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Frei used the Pulfrich refractometer with a single cell. Walpole and Hart used the Zeiss immersion refractometer. According to Kane and Watson, in order to obtain the full accuracy of which the Pulfrich refractometer is capable, it is necessary to know the compensation very closely. They overcame this difficulty by working with a double cell, one compartment being filled with distilled water and the other with the solution under examination. If this be done, provided sufficient time is allowed for the two liquids to reach the same temperature, it is only necessary to read the difference in refractive index on the micrometer and the temperature need not be measured at all. The method has the additional advantage that, owing to the position of the edge of the line being to a slight extent a matter of personal judgment, more accurate settings are possible when made on two lines in quick succession than when a considerable interval elapses between the readings.

The following results illustrate the accuracy of the method as worked out by Kane and Watson. Kahlbaum's "Gold Label" gelatin was employed with a water content of 17·5 per cent., and ash 1·8 per cent. Solutions were made at 60°, filtered, and the gelatin determined by evaporation to dryness and heating at 105° for 15 hours. More dilute solutions were prepared from the original by adding weighed quantities of water. The difference between the refractive index of the solution and that of distilled water was then read on the micrometer of the refractometer. Consecutive readings were found to differ by not more than 6 secs. The table below gives the concentration of the

Refractive Index of Gelatin Solutions at 21° *and* 29°.

G. gelatin per 100 g. water.	G. gelatin per 100 c.c.	Difference in micrometer readings.	$\delta n_D \times 10^5$	$\delta n_D \times 10^5$/g. weight.	$\delta n_D \times 10^5$/g. volume.
21°					
0·122	0·122	2·80	22	180·0	180·0
0·202	0·201	4·65	37	183·0	184·0
0·320	0·318	7·30	58	181·0	182·0
0·526	0·524	12·15	96	182·0	183·0
0·710	0·705	16·25	130	183·0	184·0
0·879	0·872	19·95	159	181·0	182·0
1·330	1·316	30·10	240	180·0	182·0
1·784	1·764	40·40	323	181·0	184·0
29°					
0·780	0·772	18·15	143	183·0	185·0
1·130	1·116	26·10	207	183·0	185·5
1·592	1·566	36·60	291	183·0	186·0
2·406	2·356	54·95	439	182·5	186·3
3·216	3·137	72·85	584	181·7	186·2

solutions, the difference in micrometer readings, the change in refractive index, which is not quite a linear function of the angular difference, and the change in refractive index per gram of gelatin for different concentrations. All measurements were made at room temperature, the first series during cold weather in the neighbourhood of 21° and the second series in hot weather at approximately 29°.

The concentration of gelatin has been given both in grams per 100 g. of water and grams per 100 c.c., the latter being calculated by Kane and Watson by means of Davis and Oakes' formula, $D_s = D_w + 0{\cdot}0029x$, for the density of a solution containing x per cent. of gelatin. It will be seen that the relation between change in refractive index and concentration is very nearly linear whichever method of expressing the latter quantity is adopted, the variation being slightly less for volume concentration. The actual values for change in refractive index per gram of gelatin agree closely with those of Walpole (182·4 at 17·5° for solutions up to 4 per cent.) and Hart (mean for different specimens of glue at 20°, 183).

5. Commercial Varieties of Glue

Joiners' Glue is either skin glue or bone glue, or a mixture of the two. *Cologne Glue* is the best and purest skin glue, and is very much in request on account of its high adhesive power. *Gilders' size* is Cologne glue in thin leaves bleached by chlorine. *Patent Glue* is a pure, dark-brown bone glue in thick tablets, without net-markings; it swells greatly in water, and serves for mouldings, buttons, and the like. *Fining Glue* is manufactured from bones in the form of thick, pale-tinted plates, and is used instead of isinglass for the fining of wine and beer. *Mouth Glue* is a better quality of bone glue, scented with lemon essence and sweetened with sugar. *Russian Glue* is a dingy white or brownish-white variety of Cologne glue, rendered opaque by the addition of white lead, zinc white, permanent white, or chalk. An improvement in adhesiveness is not aimed at by the additions.

Glazing and *parchment size* are valuable kinds of pure skin glue, resembling gelatin; parchment size is put on the market in jelly form, packed in small jars, usually with an addition of alum. *Flemish Glue* consists of thin, yellow leaves, shrunken in both directions, and is used for the production of glue colours and as a glazing material. *Paris Glue* and *Hatters' Glue* are poor, dark brown, opaque, almost always offensively smelling, soft varieties, used in hat-making because of their considerable hygroscopicity.

Liquid Glue. Thirty-eight parts of glue are dissolved in 100 parts of acetic acid; the resulting product remains in the fluid state. A preparation made with nitric acid is known as *Steam Glue*, also as *Russian light* and *dark Steam Glue*. *Glycerin Glue* is obtained by dissolving glue in warm glycerin; small additions of glycerin to steeped glue impart elasticity to the jelly, making it caoutchouc-like and suitable for hectograph compositions. *Chrome Glue* is either a mixture of glue with potassium or ammonium dichromate, or of glue with chrome alum. After drying, the former mixtures are insoluble in water. They are used for cementing glass, porcelain, and iron, for finishing and waterproofing materials, and for photographic purposes.

2. Gums

Three sorts of gums are used in the manufacture of matches—gum arabic, gum senegal and gum tragacanth.

(a) *Gum Arabic* forms irregular, brilliant, transparent, brittle pieces of a white to yellow or brown colour and varying from the size of a lentil to that of a walnut. The pieces are mostly filled with internal cracks, and are also cracked on the surface, which renders them easy to break and to powder. They do not become damp in the air, show a brilliant conchoidal fracture, and give with cold water an almost clear, viscous, slimy, slightly opalescent solution, which can to some extent be drawn out into threads, but which is neither tough nor gelatinous. The solution reacts faintly acid and is very adhesive. Gum arabic breaks up and dissolves easily in the mouth, and has an insipid and slimy taste. The solutions are thick flowing and have a good adhesiveness.

On account of its high price, it is frequently adulterated, mostly with insoluble cherry-gum, dextrin, etc., and is sometimes bleached with sulphurous acid to make it appear of better quality for certain purposes. This renders it unsuitable for the manufacture of matches. Since the conditions of export from the Sudan have become unfavourable, gum arabic is adulterated with gum senegal; indeed, according to Liebermann, the latter is often sold as gum arabic. The solution, which is generally slightly acid, is heterogeneous.

(b) *Gum Senegal* forms round fragments which are larger and more transparent than gum arabic, and have fewer cracks penetrating to their interior. The pieces frequently contain large air bubbles, formed like tears, their surface is rough and not brilliant, they vary in colour from almost white to reddish-yellow, and their fracture is coarsely conchoidal and very brilliant. It is more difficult to dissolve than gum arabic, the solution is more gelatinous and less adhesive. It mixes well with organic acids and with alkalis.

According to Liebermann, gum senegal forms either colourless pale yellow, or superficially white pieces, resembling etched glass in appearance, which, however, are bright and transparent internally. The pieces are generally long, straight, coiled, or cylindrical with concentric rings. Roundish fragments of various sizes are, however, also met with, which have the appearance as if a large drop had become incrusted with smaller pieces after solidifying.

If the gum under examination has not been artificially powdered (by pounding), it is sufficient to observe these external properties to distinguish gum arabic from gum senegal. Other gums can also be detected, in this case, according to Liebermann, by the deviation of their appearance from the above.

Gum senegal is said to be distinguished from gum arabic, apart from the above method, by its property of gradually becoming moist on exposure to the air, as also by the fact that it gives only a slight turbidity with mercurous nitrate, and is very markedly thickened by borax. According to Liebermann and Kramsky, however, the assertion that gum senegal is more hygroscopic than gum arabic is incorrect. The percentage of water in each kind of gum was determined at 105°, and the dried substance allowed to stand for twenty-four hours in moist air and again weighed. Gum arabic proved to be slightly the more hygroscopic of the two, as shown by the following data:—

	Gum senegal.	Gum arabic.
Water	13·39 g.	14·56 g.
Water absorbed in twenty-four hours by the dried samples	6·15 g.	6·34 g.

Gum senegal coagulates with a number of chemical reagents, for which reason match-heads prepared with this gum are often not very cohesive.

(c) *Gum Tragacanth* comes into commerce in many different varieties. It is tasteless and inodorous, transparent, horny and tough, so that it is difficult to powder. Only a small part actually dissolves in water; for the most part, it swells up, forming a mucilage, which is not sticky, but nevertheless is highly adhesive, and can be mixed with water if in sufficient quantity. It is therefore added to the igniting composition for matches (especially safety-matches) in small quantities, firstly, in order to keep the heavier particles in suspension, and secondly, to impart greater hardness to the glue or gum-mass after drying, and thus to protect it from climatic influences. In the preparation of mucilage from gum tragacanth a short boiling gives a more viscous solution. Prolonged boiling decreases the viscosity.

It is advisable to dry the tragacanth very thoroughly, as this renders it more brittle, and facilitates the grinding. It should be coarsely ground, because it then dissolves more readily, or rather, swells more uniformly and quickly.

Powdered tragacanth gives a turbid mucilage with 30 parts of water, and this is coloured yellow by sodium hydroxide, when the mixture is heated for a short time on a water bath. At ordinary temperatures, both powdered tragacanth and the mucilage prepared from it remain completely colourless for hours, on addition of sodium hydroxide. ~~(Reuter.1)~~ The better the quality of the gum the more readily is it precipitated by solutions of sodium hydroxide or by borax.

A cheap substitute for tragacanth, discovered by Boschau, is a mixture of 20 parts of starch, 6 parts of glue, and 2 parts of glycerin, boiled in water, which is stated to be quite as efficient as tragacanth in its action. Semi-soluble gums and various mucilages such as that from Carraghin moss or Iceland moss have practically no application in the match industry, as they are difficult to prepare without suspension and they easily ferment.

There is no direct chemical method of determining the values of gums. The following, however, are useful tests and give some information regarding the gums: (*a*) ash content, (*b*) acidity, (*c*) moisture content, (*d*) keeping property of the gum. A good procedure to follow in testing is as outlined by Garner. The moisture is determined by heating 1 g. at 110° for four hours. Absence of moisture may indicate too friable a condition, so that the gum may powder too readily. The dried sample is then ignited, when the ash content should be less than 3 per cent. A larger value would indicate mineral addition. The ash consists mainly of the carbonates of calcium and magnesium. According to Garner the most important test in the evaluation of gum is the viscosity test and he recommends the following method in carrying it out.

Four g. of a typical sample of tragacanth is added to 50 c.c. water and allowed to steep for two days. The volume is then made up to 500 c.c. and the liquid passed through fine muslin. The resulting sieved mucilage is allowed to stand for an hour to become homogeneous. The viscosity is then determined in the usual way with a Redwood's viscometer. The calculations are as follows :—

A is standard sample at P shillings per cwt. B is outside sample at Q shillings per cwt. 50 c.c. of an *a* per cent. solution of A takes *x* secs. 50 c.c. of a *b* per cent. solution of B takes *y* secs. Then 100 parts by weight of A give the same viscosity as $\frac{100bx}{ay}$ parts of B, and hence the equivalent weight of B to give the same viscosity as 100 parts of A should cost $\frac{Qbx}{ay}$ shillings. This relation only holds when the difference between *x* and *y* is only a few seconds. For greater differences the stronger solution should be diluted before determination of the viscosity.

3. Dextrin

Dextrin is obtained by the treatment of starch with dilute acids, or by prolonged heating of the mixture with water to from 200° to 250°. It forms a white, yellow, or brown powder, according to the method of preparation and the temperature employed, and should be completely soluble in water. The solution is optically active; its specific rotation $[\alpha]$ is approximately +200. Several varieties of dextrin are known. Variation in the treatment of the starch breaks down the complex polysaccharide to various stages, so that the term dextrin does not represent a single substance. The more drastic breakdown gives products which do not give a reddish-brown colour with iodine. The presence of any maltose, which is recognisable by its sweet taste, renders the dextrin useless for the manufacture of matches, since maltose makes the match-heads hygroscopic and ultimately incapable of ignition. White dextrin is almost useless for this purpose, the most suitable apparently being of a light brown colour. Dextrin should not be hygroscopic; it should be inodorous, insipid in taste, and should form a mobile powder which is easily soluble in water. Dextrin is insoluble in alcohol.

The aqueous solution should be colourless, completely clear, and neither acid nor alkaline. It should give no blue or violet colour with iodine solution, no turbidity with lime water, and no precipitate with tannic acid and baryta water (soluble starch), or with lead acetate. When heated on platinum foil, it should burn without any residue. A blue or violet coloration with iodine indicates unaltered starch or soluble starch. The presence of lime is detected by the addition of ammonium oxalate, oxalic acid by lime water, gum arabic or mucilage by lead acetate. It does not form an osazone with phenylhydrazine.

Hanofsky recommends the following procedure for testing commercial dextrin :—

1. *Determination of the Constituents Soluble in Cold Water.* Twenty-five g. of the substance shaken with cold water in a flask of 500 c.c. capacity, filled to the mark allowed to settle, filtered through a folded filter and the solution used for the determination of maltose,

dextrin, and acidity. The maltose is best determined gravimetrically by Fehling's solution, the solution being boiled for five minutes. The solution is diluted to a quarter of its original strength (10 c.c. Fehling's solution and 40 c.c. water). A preliminary determination is made, to determine how much of the solution is necessary to reduce 10 c.c. of Fehling's solution, and in the second determination, 1 to 2 c.c. less than this quantity are taken and diluted until the whole volume is 57 to 58 c.c.; 113 parts of copper correspond to 100 parts of anhydrous maltose; hence, when the solution is diluted to one fourth, 113 parts of copper correspond to 91·3 parts maltose, or 1 part of copper corresponds to 0·80 parts of maltose, from which the content of maltose M per 100 g. of the original substance is calculated. For the determination of the dextrin, 50 c.c. of the solution (or 100 c.c. if the quantity of insoluble matter is large) are diluted to 200 c.c. and boiled gently under a reflux condenser with 15 c.c. of hydrochloric acid of sp. gr. 1·125 for two hours. The liquid is then neutralised in a flask of 300 or 500 c.c. capacity, diluted to the mark, and the dextrose determined with Fehling's solution. If the quantity of dextrose found in 100 g. of substance is D, the quantity of dextrin present in the original substance is 0·9 (D−1·05 M), since 20 parts of dextrose correspond to 19 parts of maltose. The acidity is determined by titrating 50 c.c. of the solution with *N*/10 potassium hydroxide, using phenolphthalein as indicator. A certain error is introduced, if the volume of the residue in the flask is neglected, but in most cases it is unnecessary to take this into account. If, however, the quantity of insoluble matter is very great, a correction should be applied. If the sp. gr. of the residual starch be assumed to be 1·6, the volume of liquid to be deducted from 500 c.c. is, $V = \frac{p}{1 \cdot 6}$, where p is the quantity of starch in 25 g. of substance. If the quantity of starch is 40 per cent., this volume is only 6·2 c.c.

2. *Determination of the Insoluble Matter.* This consists almost exclusively of starch. Two and a half to three g. of substance is boiled gently for two hours with 200 c.c. of water and 15 c.c. of hydrochloric acid of sp. gr. 1·125, whereby starch, dextrin and maltose are converted into dextrose. The dextrose is determined with Fehling's solution after neutralising and diluting to 300 or 500 c.c. If the quantity of dextrose found for 100 g. substance is D_1, the percentage of starch is calculated as 0·9 (D_1-D).

If the moisture, determined by drying at 110°, is W per cent., and the ash A per cent., the quantity of " other organic compounds " is :— 100−(maltose+dextrin+starch+W+A).

W. Jettel obtained the following results in several dextrins by this method :—

	Maltose.	Dextrin.	Starch.	Water.	Ash.	Other organic compounds.	Acidity. c.c. *N*/10 potassium hydroxide.
I.	4·25	47·78	35·55	10·11	0·27	2·04	40·0
II.	10·90	36·75	43·20	7·02	0·39	1·74	26·6
III.	3·75	29·46	58·00	6·85	0·60	1·34	25·3

Undecomposed starch may be detected microscopically and by its insolubility in water. There is generally a small amount of reducing material present from maltose, etc. It may be estimated by Fehling's solution.

It is very difficult to wash dextrin free from starch, and filtration is slow. In any analytical method which involves these operations special precautions must be taken or results are unreliable. A practical method for the determination of dextrin gum has been devised by Babington, Tingle and Watson, which is comparatively rapid and accurate, within 5 per cent. with most commercial samples. The sample (1 g.) is warmed in a 100 c.c. graduated flask with 30 c.c. of water until just gelatinised and then rapidly cooled. Fifty c.c. of a cold saturated solution of barium hydroxide is next added and the volume made up to 100 c.c. Fifty c.c. of the filtered solution is placed in a platinum dish. After the addition of 2 drops of a 1 per cent. phenolphthalein solution, *N*/1 hydrochloric acid is added to neutralisation point. A faint pink colour is restored by adding two or three drops of the barium hydroxide solution. Approximately 10 g. of sand is added and the dish heated on a water bath. The sand should be stirred when almost dry, to expose the maximum surface to the air, after which the dish is transferred to a well-regulated oven and dried to constant weight at 120°. The dish is now heated strongly to burn the organic matter completely. The dish is then cooled and weighed. The difference in weight before and after ignition represents the dextrin gum in 50 c.c. of filtrate.

TESTING AND DIFFERENTIATION OF GUM ARABIC, GUM SENEGAL, AND DEXTRIN

Liebermann gives the following procedure for this purpose :—

1. External examination of gum arabic which has not been artificially powdered.

2. External examination of gum senegal.

3. Both forms of gum are completely soluble in water ; only particles of wood remain behind, which are generally reddish in the case of gum arabic, and blackish in the case of gum senegal. These particles of wood are found even in very pure specimens of gum. Other varieties of gum, as, for instance, that of the cherry tree, dissolve only partially in water. A swollen mass remains behind, which dissolves only on prolonged boiling or very long digestion.

4. The aqueous solutions of both sorts of gum give a bluish precipitate with potassium hydroxide and a few drops of copper sulphate ; but this is much more pronounced in the case of gum arabic, and collects in large flakes which rise to the surface in the test-tube, whereas the precipitate obtained with gum senegal is less pronounced, and consists of small flocculi, which remain more uniformly distributed throughout the liquid. These precipitates dissolve but slightly on warming, and no reduction occurs even on vigorous boiling.

5. Solutions of dextrin also give bluish precipitates with potassium hydroxide and copper sulphate, which do not dissolve on shaking in the cold, but dissolve completely on heating, giving rise to clear, dark blue liquids. On boiling for some time, complete reduction of the copper oxide occurs.

6. On prolonged heating with dilute potassium hydroxide in a test-tube, solutions of gum arabic and dextrin become amber yellow, whereas solutions of gum senegal are scarcely coloured, or assume only a faint yellow tint.

7. Mixtures of gum arabic and gum senegal behave towards potassium hydroxide and copper sulphate solution in the same way as gum senegal alone ; on boiling with potassium hydroxide alone, however, they behave like gum arabic solutions, the liquid becoming amber yellow.

8. Solutions of mixtures consisting of gum-arabic and dextrin behave like gum arabic towards potassium hydroxide and copper sulphate, as regards the appearance of the precipitate. On boiling for some time, however, reduction takes place, if the quantity of dextrin is not too small. The same applies to mixtures of gum senegal and dextrin.

9. If the quantity of dextrin be too small, the reduction may not take place. In such cases the precipitate obtained with potassium hydroxide and copper sulphate must be filtered off, after moderate warming. The filtrate, which contains no gum, but is still somewhat milky and turbid, is boiled. A distinct separation of red cuprous oxide (or yellow hydroxide) shows the presence of dextrin.

10. The separation must be carried out in the same way, when mixtures of both sorts of gum with dextrin are under investigation. The copper precipitate, containing the acid gum products, is washed with distilled water, dissolved in hydrochloric acid, and this solution

precipitated with excess of alcohol. The precipitate is allowed to subside for one and a half to two days, the liquid then decanted and the transparent disc of gum, which remains at the bottom of the vessel, washed with alcohol. The small quantity of alcohol remaining behind is allowed to evaporate ; or, the gum is dissolved directly in hot water and the aqueous solution tested for gum arabic or gum senegal, as indicated in Nos. 4, 6, and 7

Lead sub-acetate precipitates gum arabic in aqueous solution. In presence of sugar, addition of alcohol prevents the precipitation of dextrin if the latter is present.

The Examination of Gum Arabic can also be carried out as follows :—

A. Appearance of the gum, according to 1 and 2, if the gum has not been pulverised.

B. Solution of the powdered substance in lukewarm water. Observations as in No. 3. If the substance dissolves only partially, leaving a swollen gelatinous mass, it consists of cherry gum or a similar "gummi nostras," or of a mixture containing such gums. If the substance dissolves, all but a turbidity and a few particles of wood, proceed to :—

C. The aqueous solution is treated with excess of potassium hydroxide and some copper sulphate, gently warmed, and filtered :—

(*a*) *The Filtrate*, which may contain dextrin, is tested according to No. 9.

(*b*) *The Precipitate* is examined as in No. 10. If the aqueous solution of gum acids, prepared as described in No. 10, be treated with an excess of potassium hydroxide and some copper sulphate added, a precipitate results, which either agglomerates and rises to the surface, or remains in the form of small flakes uniformly suspended throughout the liquid.

Precipitate Agglomerates.	*Precipitate does not Agglomerate.*	
Gum arabic. (The aqueous solution becomes amber yellow on treatment with potassium hydroxide.)	Gum senegal, or a mixture of gum senegal and gum arabic. (The aqueous solution is boiled with potassium hydroxide.)	
	Amber Yellow Colour. — Mixture of gum arabic and gum senegal.	*No Colour, or Pale Yellow.* — Gum senegal.

In Thevenon's test for gum tragacanth the presence of 5 per cent. gum arabic in gum tragacanth can be observed. A small amount of the mixture is warmed with water and an equal volume of 4 per cent. pyramidon solution added, followed by 10 drops of hydrogen peroxide (12 per cent.). In 5 to 30 minutes a blue colour develops, depending upon the amount of gum arabic in the sample. For quantitative tests a control is done with gum tragacanth of known purity with varying amounts of gum arabic present.

Detection of Gum Substitutes. Many good, strongly adhesive gums have come on the market only in small quantities. As a consequence, substitutes have been exported in large quantities from South America, Australia, etc. Some of these have served the purposes of gum satisfactorily for some technical uses ; they proved to be easily soluble, but were all inferior to genuine gum arabic in adhesiveness. Some kinds, however, although of inviting appearance, proved to be quite insoluble, only swelling up when placed in hot water. It has been pointed out that such gums could be rendered soluble by boiling under high pressure. This is probably correct, but gum so dissolved possesses a very inferior adhesive power, not even equal to that of starch paste; it could therefore be used only for thickening; even in this case starch or tragacanth is greatly preferable.

When such gum substitutes come in the unmixed state into the market, they are easily recognised; but when ground to a coarse powder, and mixed with an equal part of genuine gum gheziri, a simple solution test does not show the presence of substitutes, since the swollen gelatinous particles of the substitute remain suspended, and are completely invisible. In order to detect such adulteration with certainty, the following simple method may be recommended.

The suspected gum is covered with ten times its quantity of hot water, and allowed to stand for three or four hours, with frequent stirring. When the insoluble matter has subsided, half the liquid is poured off, replaced by the same quantity of cold water, and again well stirred. This process is repeated twice within an hour. The last mixture separates after short standing into two parts, the upper layer consisting of water, and the lower layer of a gelatinous, highly refractive mass. In this way, the presence of even 5 per cent. of adulterant can be detected with certainty.

4. Other Adhesives

Among substances which have been suggested as adhesives are (*a*) casein (B.P. 362001/1930; U.S. Pat. 1886750/1933), (*b*) rubber latex (French Pat. 735348/1932), and (*c*) Hydroxyalkyl ethers of carbohydrates (B.P. 389534/1933).

E. COLOURING MATTERS

Red lead, manganese dioxide, ochre, umber, smalt, ultramarine, and various coal-tar dyes are employed.

IV. MATERIALS FOR THE STRIKING SURFACE

These are the same as for the match compositions. Manganese dioxide, the sulphides of antimony, powdered charcoal, amorphous phosphorus, potassium chlorate, glass powder, etc., as frictional materials; chalk, etc., as filling materials; umber and the like as colouring matters; glue, gelatin, and dextrin as binding materials.

V. MATCH COMPOSITIONS

A. COMPOSITIONS FOR MATCHES WHICH STRIKE ON ANY SURFACE

This class includes not only matches made with ordinary phosphorus, but also matches free from phosphorus, and those which contain red phosphorus, with or without sulphur and phosphorus sesquisulphide. For a great number of years attempts have been made to eliminate the use of phosphorus, and of special striking surfaces. Many of the proposed substitutes for phosphorus, however, have been too expensive, some too little inflammable, some too unstable, and some only available for paraffined matches.

In those match compositions which contain no white phosphorus, sulphur is mixed with such substances as amorphous phosphorus, phosphorus sesquisulphide, antimony sulphide, thiocyanates, and cyanides of metals, etc.; or, easily inflammable substances, like charcoal, the salts of fatty acids (stearates), carbon compounds, such as naphthalene and phenanthrene, as well as shellac and resins. As oxidising agents, besides those already mentioned, such as potassium permanganate and nitro-compounds, gun-cotton, aromatic nitro-compounds, such as trinitrophenol (picric acid) and picrates, have been tried. These last substances are explosives; their properties are described in the section on Explosives (p. 43). Chlorates and perchlorates have also been used as oxidising agents in match compositions. So as to retard the combustion and to insure a complete ignition of the composition, a small quantity of a complex metallic cyanide, such as Prussian blue, Turnbull's blue, or even the material used in gas purification, is added; this contains free sulphur, thiocyanates, and complex metallic cyanides.

Rossel gives the following two recipes for the preparation of match compositions:—(1) 10 parts of potassium chlorate, 7 parts of pure and freshly precipitated lead thiosulphate, 2·5 to 2·9 parts of antimony trisulphide, 0·25 parts of gelatin. (2) 300 parts of powdered glass, 120 parts of manganese dioxide, 160 parts of potassium dichromate, and 90 parts of flowers of sulphur; these are mixed together in water and finely ground. In another case 300 parts of gum arabic and 210 parts of glue are dissolved in water, and 1800 parts of well-powdered and sieved potassium chlorate are added; the following substances are then added consecutively, each being finely powdered:—600 parts of lead thiosulphate, 450 parts of red lead, and 25 parts of barium thiosulphate. Rossel gives particulars also of the following composition, containing red phosphorus:—450 parts of potassium chlorate, 100 parts of potassium dichromate, 75 parts of powdered glass, and 60 parts of sulphur (washed flowers of sulphur or powdered roll-sulphur), 25 parts of *caput mortuum* (iron oxide), 7 to 8 parts of red amorphous phosphorus, 110 parts of gum arabic, and 30 parts of gum tragacanth.

Craveri has proposed the use of persulphocyanic acid, which is supposed not to react when hammered or rubbed, is claimed to be non-poisonous and harmless during the manufacture of the match compositions, and cheaper than phosphorus.

The composition made by Bohy, Gallay, & Co., of Nyon, contains salts of hypophosphorous acid, mainly the calcium salt, in place of ordinary or amorphous phosphorus. Calcium, barium, and strontium hypophosphite ignite only at a high temperature; if, however, they are mixed with potassium chlorate or nitrate, or any other oxidising agent, ignition takes place very readily. This composition is made as follows:—210 g. of glue and 30 g. of gum tragacanth are allowed to soften for twelve hours in water, then warmed and boiled; 25 g. of turpentine is added, then 1 kg. of potassium chlorate, 200 g. of sulphur, 150 to 200 g. of a hypophosphite (calcium, barium, or strontium salt), 5 to 10 g. of potassium dichromate, 125 to 150 g. of barium chromate, 200 to 250 g. of powdered glass, and 10 g. of colouring matter. Another composition can be obtained by the further addition of 150 g. of naphthol yellow, or in place of this, 100 g. of picric acid.

Another match composition is made up of barium chlorate, sulphur, inert matter, and a binder, the amount of barium chromate being approximately twice that of the potassium chlorate.

Even before Sévène and Cahen, Rals had recommended fusing together sulphur and red phosphorus, but the result was not equivalent to phosphorus sesquisulphide. The Sévène-Cahen process was taken up by the French Government, and it is said that the French public did not notice any difference, on the introduction of the so-called " S. and C." matches, containing this substitute for phosphorus.

The " S. and C." composition varies, according to whether it is to be used for paraffined or sulphured splints, or for waxed threads. The ordinary composition is as follows:—6 parts of phosphorus sesquisulphide, 24 parts of potassium chlorate, 6 parts of zinc oxide (zinc white), 6 parts of red ochre, 6 parts of powdered glass, 6 parts of glue, and 34 parts of water. It is easy, by manipulation, to make these matches either more or less inflammable. The mechanical processes are much the same as in the manufacture of phosphorous matches.

In Aronson's composition a small proportion of potassium oxy-salts are used with a relatively large proportion of phosphorus mixed with an equal proportion of lamp-black or other non-glowing material, and binding agent (dextrin).

The Chemische Fabrik Griesheim-Elektron has placed on the market a product, called " Sulfophosphit," which consists of zinc, phosphorus, and sulphur. It is stated that both paraffined and sulphured matches can be made with this substance, with any required degree of inflammability. " Sulfophosphit " is claimed to be more stable, under atmospheric influences, than red phosphorus and phosphorus sesquisulphide; also, the price is alleged to be low.

The basis of another dipping composition, made by R. Gans, is a mixture of "sulfocuprobariumpolythionate" and potassium chlorate. The composition is said to be comparatively insensitive to warmth, and to keep for a long time. The splints, after dipping, are coated with a spirit or water varnish. This new composition is said to be more inflammable than that of Schwiening.

B. COMPOSITIONS FOR SAFETY MATCHES WHICH REQUIRE A SPECIAL STRIKING SURFACE

Brown Safety Match Composition (Kellner). One hundred and fifty parts of gum senegal are dissolved in 200 parts of water, and at the same time 20 parts of powdered tragacanth are digested in 300 parts of water for twenty-four hours; these solutions are united and boiled, and 100 parts of powdered and sifted potassium chlorate introduced. To this is added a finely powdered and thoroughly mixed mixture of 125 parts of potassium dichromate, 30 parts of sulphur (crushed roll-sulphur or washed flowers of sulphur), 33 parts of antimony trisulphide, 50 parts of powdered colophony, 200 parts of minium or of lead peroxide 100 parts of umber or terra di Sienna, 100 parts of powdered glass or powdered pumice stone, and lastly 150 parts of hot water.

Composition for the Striking Surface.—Four hundred parts of dextrin are mixed with 400 parts of water, boiled, and allowed to cool; with this is mixed a thin paste of red phosphorus, which has been made by stirring 1000 parts of red phosphorus with 2000 parts of water, allowing to stand, and pouring off the excess of water. Then 200 parts of prepared chalk (the mass swells up, owing to evolution of carbon dioxide), 300 parts of umber, and 1000 parts of finest powdered antimony sulphide are added, and the whole mixture passed through a mill.

Rossel used the following composition:—Ten parts of gum arabic, 300 parts of gum tragacanth, 53·8 parts of potassium chlorate, 6 parts of *caput mortuum*, 12 parts of powdered glass, 5 parts of potassium dichromate, 3 parts of sulphur, 1·2 parts of chalk or colophony, and 6 parts of manganese dioxide. The striking surface for this composition consisted of 5 parts of antimony sulphide, 3 parts of amorphous phosphorus, 1½ parts of manganese dioxide, and 4 parts of glue.

Moisture-proof striking surfaces are formed by mixing the active substances with a solution in an organic solvent of a hardening insoluble non-combustible binding agent.[2]

A phosphorus-free striking surface, recommended by Craveri,[3] on which any safety-match will ignite, is made up as follows:—Two parts of a thiocyanate compound, 1 part of persulphocyanic acid, 0·5 parts of potassium xanthate, 4 parts of antimony sulphide, and as a binding material, 1 part of gelatin.

Many different types of matches or match substitutes have been suggested from time to time, but they have not come into general use. As one example of this type, reference may be made to "rods" capable of ignition by friction.[4] The rods can be extinguished and re-ignited repeatedly. They comprise a foundation of organic substances, ash free and having a speed of combustion less than that of a low nitrated cellulose. A typical mixture of this class consists of cellulose nitrate or acetate mixed with ammonium oxalate, camphor, or naphthalene and an ignition mixture free from phosphorus (*e.g.* potassium chlorate and sulphur). Additional substances, as binders, combustion regulators, filters, pigments, etc., may also be added.

VI.—THE CHEMICAL EXAMINATION OF MATCH COMPOSITIONS

The composition, when examined under the magnifying glass, should be as uniform as possible, and it is important that no particles of phosphorus should be visible.

The following method of examination is recommended by Bolley, for the purpose of determining the constituents of a match composition. The matches are placed in water at a maximum temperature of 20°, in a porcelain basin, the swollen heads removed by mechanical means, and after having been broken up under the water, digested and continually stirred (in the absence of phosphorus, the mixture can be boiled), and then separated by filtration.

1. The filtrate, which may contain potassium chlorate, potassium nitrate, lead nitrate, potassium chromate, potassium ferrocyanide, gum, glue, and dextrin, as well as other substances that are soluble in water, is divided into several portions. One of these is tested for lead, another for chlorate. Another portion is evaporated and ignited; if the residue, on moistening, gives an alkaline reaction, a nitrate is present. Ferrocyanic acid is tested for with a ferric salt. To determine the presence of gum or glue, a rather larger portion of the same filtrate is evaporated to dryness with sodium hydroxide; on heating a portion of this residue in a tube, the presence of glue or albuminous matter is indicated by the evolution of ammonia gas, which can be tested for in the usual manner, either by smell, or with hydrochloric acid, or with turmeric paper. Gum and glue are precipitated from the solution on addition of alcohol. The presence of dextrin in the solution is determined by the addition of a few drops of a solution of iodine, when a pale reddish-blue coloration is formed.

2. The residue on the filter paper is digested with alcohol, so as to extract stearic acid, paraffin, and resins. To extract wax, it is necessary to boil with the alcohol; this is not permissible, however, in the presence of phosphorus. The alcoholic filtrate, after evaporation, yields a substance, from the consistency, melting point, etc. (solubility in ether, fractional crystallisation, and melting point), of which conclusions can be drawn as to the nature of the residue. If phosphorus is present in the residue it can be removed before the digestion with alcohol, by treatment with nitric acid to convert it into phosphoric acid, which is recognisable by the usual means.

Matches containing phosphorus become luminescent in the dark, and when moistened with water, give the characteristic smell of phosphorus.

3. The original residue, which remains after the digestion with water, will evolve chlorine on heating with hydrochloric acid, if lead peroxide, red lead, or manganese dioxide be present; the smell of sulphurous acid denotes sulphites, and lead, manganese, iron, and antimony can be tested for in the residual solution. The presence of lead peroxide, or of red lead, is recognised from the colour of the match-head. Ochre remains partly, and smalt completely, undissolved; both can be recognised with the blowpipe, whereas ultramarine is decomposed by hydrochloric acid, evolving sulphuretted hydrogen. Charcoal, sand, and powdered glass remain undissolved in hydrochloric acid, and can be identified with a magnifying glass; sulphur can be recognised by its colour, by the smell on burning, or it can be extracted with carbon disulphide.

A. EXAMINATION FOR PHOSPHORUS

The recognition of phosphorus is very much simplified by its luminosity in the dark; but with a small quantity of phosphorus in a very large quantity of matter, for instance, in poisoning cases, either in a quantity of food, or in the stomach contents, this luminescence does not show, even when friction is applied. The material is firstly examined for an odour of phosphuretted hydrogen or of ozone, which would denote the presence of free phosphorus. It should be examined by Scherer's test as follows:—Strips of paper, soaked respectively in a 5 per cent. silver salt solution and in an alkaline lead solution (5 per cent.), are hung up over the material for examination. If phosphorus is present, the silver paper only will be blackened; should both papers turn black, the presence of sulphuretted hydrogen is proved, but not the presence of phosphorus; that is to say, this test for phosphorus fails in the presence of sulphuretted hydrogen. Even when a positive test is obtained the results must be confirmed otherwise, preferably by Mitscherlich's test. Attempts can also be made, by treating the matter with water, to collect any minute floating particles of phosphorus in a filter, and if this is successful, they can be oxidised by nitric acid to phosphoric acid and tested for in the usual way. The material may also be treated with a small amount of benzene and a strip of paper 10 cm. by 3 cm. soaked in it. This is then suspended in a glass tube connected to a Victor Meyer's heating apparatus and exposed to a current of air at 40° to 50°. Even when the benzene solution contains not more than 0·01 mg. of white phosphorus per c.c. the paper will become luminescent when examined in the dark.

The following method, however, due to Mitscherlich, is satisfactory:—The mass is acidified with sulphuric acid, and distilled with steam, the vapours being passed through a vertical condenser; if phosphorus is present, it is vaporised with the steam, and can be recognised as a luminescent ring, which moves up and down in the condenser. The test is conducted in a darkened room; it is possible by this means to detect 0·00001 parts of phosphorus. It is often possible to find small particles of phosphorus in the distillate, and to obtain the test for phosphorous acid. The phosphorus and phosphorous acid are treated separately with strong chlorine water, and thus oxidised to phosphoric acid, which is estimated in the usual manner with magnesia mixture, as ammonium magnesium phosphate.

Care must be taken in carrying out this test that alcohol and ether, should they be present, do not prevent the luminescence of the vapours. Turpentine and other volatile oils, as well as phenol and creosote, often completely prevent it; furthermore, red phosphorus does not produce this luminescence, but mixtures of sulphur and phosphorus, such as are found in match-heads, will cause it. According to Polstorff and Mensching, the luminescence is also hindered by the presence of mercury salts. Copper salts and sulphuretted hydrogen also are said to interfere. Even after continued distillation, the whole of the phosphorus will not be found in the distillate; O. Schifferdecker calculates that for every milligram of phosphorus in the distillate, the original substance contained 1·5 to 2·0 mg.

According to K. Fischer, the presence of potassium chlorate in match compositions greatly interferes with the testing for phosphorus, and it is advisable to wash the sample several times with cold water to eliminate the chlorate, before distilling. If substances soluble in water are to be determined, the two tests can be combined. The washing with water can be avoided by using tartaric acid for the distillation instead of sulphuric acid; the presence of potassium chlorate does not then influence the phosphorus test.

Another means of detecting phosphorus, described by Dusart and Bloudlot, is based on the fact that small quantities of phosphorus, phosphorous acid and silver phosphide, give with nascent hydrogen, phosphuretted hydrogen, which can be recognised by the emerald green colour imparted to the hydrogen flame when a porcelain basin is held in it. The hydrogen must be free from sulphuretted hydrogen, and must be passed through a tube containing pumice-stone soaked in potassium hydroxide, before lighting, otherwise the flame would appear blue; the gas exit tube should have a platinum-covered tip, as the sodium contents of the glass will otherwise colour the flame. The substances containing phosphorus must not be introduced directly into the hydrogen-generating mixture, as they easily prevent the formation of the green flame. But the phosphorous acid or phosphorus particles obtained by Mitscherlich's test, can be introduced into a suitable mixture of zinc and dilute sulphuric acid; or silver phosphide, which is obtained as a black powder by heating the acidified phosphorus-containing matter in a current of carbon dioxide, and passing the gas into a solution of silver nitrate, may be so introduced. The green flame appears in the presence of the smallest trace of phosphorus, and, according to Christofle and Beilstein, gives a spectrum with three green lines, of which the two strongest are in the green, and the weakest in the yellow. Dusart's test has been modified by Dalmon in such a manner that the whole of the organic matter containing phosphorus is treated with hydrogen. The gas is passed through a long drawn-out glass tube, bent upwards at right angles, and is lighted at the end; if a narrow glass tube is pushed over the jet, the flame shortens, and appears green, for the whole length of the tube, and when the tube is pushed down further, the flame shortens still more, becomes dark blue, and if the glass tube is slowly drawn away at this moment, a magnificent emerald-green flame-ring appears, passing up the tube with greater or less velocity. The phosphorus-charged hydrogen, generated in this way, luminesces in a dark room, without the gas being ignited.

In Schloesing's test for free white phosphorus in phosphorus sesquisulphide the latter is shaken with light petroleum (b. pt. 45°) to dissolve free phosphorus. The liquid is quickly filtered and an aliquot part evaporated in a vacuum at 15° to 20°. The residue is oxidised with nitric acid and the phosphorus estimated. In order simply to detect the presence of phosphorus, the residue after evaporating off the petroleum is shaken with fine sand in a flask in the dark and carefully examined for phosphorescent glow.

With regard to the period during which phosphorus will remain in organic matter and can be tested for, Medicus gives the following data:—Neumann found phosphorus in a corpse after it had been buried for fourteen days. Dragendorff mentions a case, in which he was able to detect phosphorus in the secretions in a corpse that had been buried for several weeks and afterwards exhumed. Fischer and Müller were able to detect phosphorus in the body of a guinea-pig, which had been buried for eight weeks. On the other hand, Herapath was unable to detect a trace of phosphorus twenty-three days after death; Brandes could find no phosphorus in the corpse of a child after three weeks, but could detect its acids. Medicus was able to detect phosphorus for half an hour by Mitscherlich's test twenty-three days after poisoning; the sulphuric acid solution, after filtering, gave a gas containing phosphorus on treatment with zinc and hydrochloric acid.

B. TESTING FOR ORDINARY PHOSPHORUS IN MATCH-HEADS

Prohibition of the Use of White Phosphorus.—Subsequent to conferences held at Berne in 1905-6, certain European countries discontinued the use of white phosphorus in the manufacture of matches. In Germany a law that white phosphorus should cease to be used for the manufacture of matches after 1st January 1907 was approved. In the United Kingdom the "White Phosphorus Matches Prohibition Act (8 Edward VII., 1908, chapter 42)" was passed on 21st December 1908, and came into force on 1st January 1910. According to this Act:—"It shall not be lawful for any person to use white phosphorus in the manufacture of matches, and any factory in which white phosphorus is so used shall be deemed to be a factory not kept in conformity with the Factory and Workshop Act, 1901. . . . It shall not be lawful for any person to sell or to offer or expose for sale . . . any matches made with white phosphorus. . . . It shall not be lawful to import into the United Kingdom matches made with white phosphorus, and matches so made shall be included among the goods enumerated and described in the table of prohibitions and restrictions contained in section 42 of the Customs Consolidated Act, 1876."

Detection of White Phosphorus.—It is now necessary, therefore, to test for white phosphorus in match-heads, in cases where its presence is suspected. Hitherto no exact method has been advanced, suitable for the detection of white phosphorus under all conditions.

On the one hand, the examination of phosphorus sesquisulphide, which is frequently present, is, according to Friedheim, difficult, because the sulphur-phosphorus compounds gradually decompose into compounds containing less sulphur, with separation of white phosphorus, and on the other hand, the detection of phosphorus in matches in presence of potassium chlorate cannot be carried out by the ordinary methods of analysis.

In some cases it is possible, when examining match-heads stated to contain no white phosphorus, and to which no white phosphorus has been added as such, to demonstrate the presence of this substance, yet it cannot be ascertained whether it was added, or whether it was re-formed from phosphorus sesquisulphide. Again, in other cases, no phosphorus may be detectable, notwithstanding its presence, because the test sometimes fails in presence of potassium chlorate (*cf.* p. 135).

To test for ordinary phosphorus, at least twenty-five match-heads are placed directly in a Mitscherlich apparatus, with 50 c.c. of water and 10 c.c. of dilute sulphuric acid. The mixture is heated over a flame, without the introduction of steam (*cf.* p. 134); if potassium chlorate is present, the phosphorescence may not appear (*cf.* p. 135); but on the other hand, phosphorus sulphide is capable of producing a luminescence which, though different from that caused by phosphorus, may be mistaken for it. In the first case, either the substances soluble in water, including the potassium chlorate, must first be removed from the match-heads with cold water, or the test must be carried out with tartaric acid. To determine the presence of very small amounts of yellow phosphorus in red phosphorus the following test has been proposed by Kray :—

20 g. of the red phosphorus product is dissolved in 30 c.c. of carbon disulphide and filtered. Part of the filtrate is tested with filter paper which has been impregnated with copper sulphate solution; the depth of the brown colour is a measure of the amount of yellow phosphorus present.

To test for ordinary phosphorus in the presence of phosphorus sulphide (phosphorus sesquisulphide, P_4S_3), the following process, due to R. Schenck and E. Scharff, can be employed. This method is based on the property of ordinary phosphorus, when oxidised to phosphorus trioxide, of ionising the air, which then becomes capable of conducting electricity. Phosphorus and sulphur compounds, even if they luminesce, do not produce this effect.

The apparatus employed (Fig. 9) consists of two parts, connected by a glass tube, viz., the vessel *a*, for generating the phosphorised air, and the electroscope *b*. The former is a test-tube with a side connection, and a ground glass stopper, through which the air delivery tube passes, reaching nearly to the bottom of the test-tube. A glass tube is attached to the side connection by means of rubber tubing, which delivers the phosphorised air to the cylindrical condenser *c*, the removable top *d* of which carries the electroscope. Within the outer cylinder *c* is an insulated cylindrical disperser (*zerstreuungkörper*) suspended from the electroscope.

The phosphorus oxidation products are prevented from entering the inside of the electroscope case *b*, from *c*, by two insulated plates, which can be removed and cleaned, and through which the carrier of

the disperser passes and fits closely. A small piece of sodium is put in *c* to prevent access of moisture. A rod, by means of which the disperser can be charged, which is well insulated and has a properly insulated handle, passes through the lid of the cylinder *c*.

To charge the electroscope, the rod is pushed down close to the disperser, and Zamboni's dry pile brought up to it and then removed; after charging, that is, when the aluminium leaves of the electroscope are apart, the rod is drawn up again.

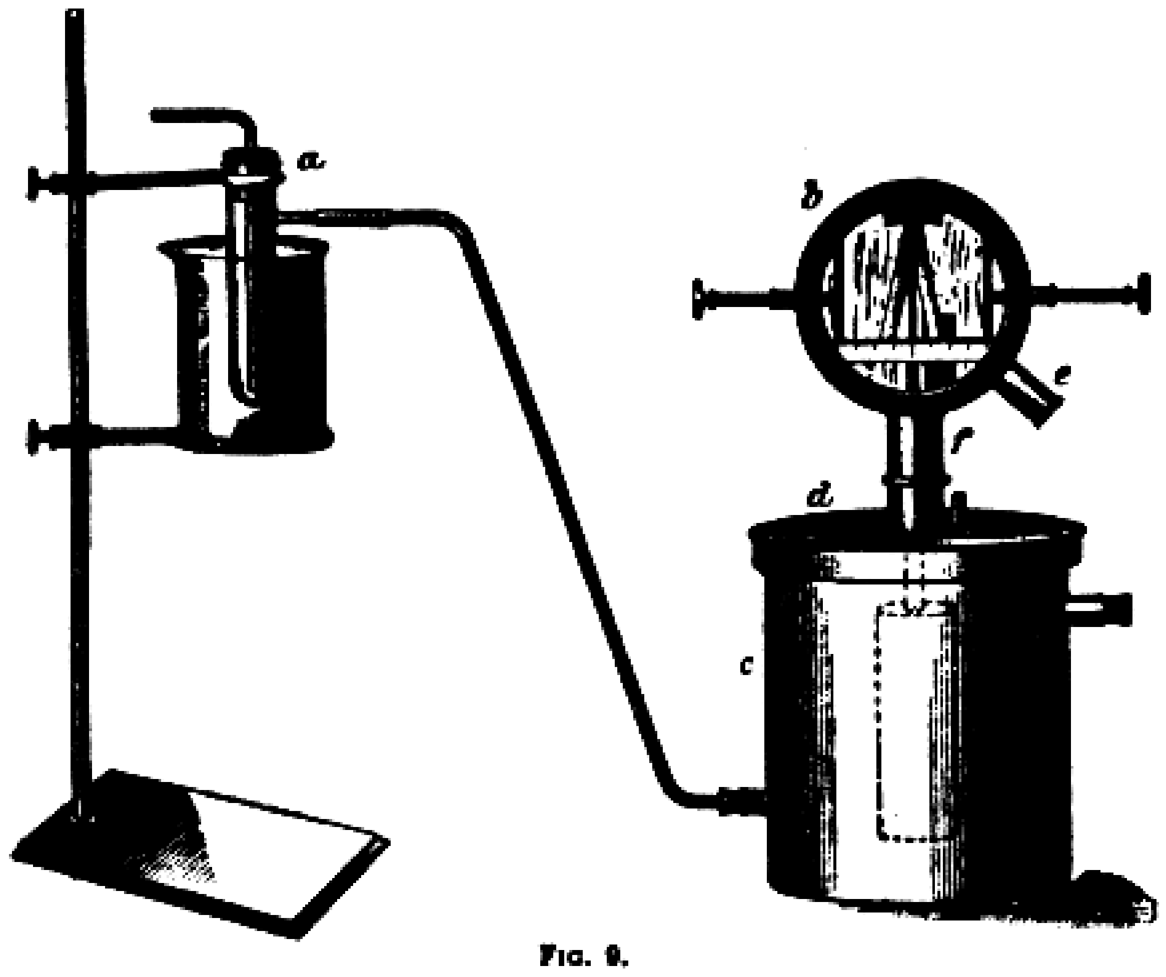

Fig. 9.

To carry out the test, some of the match composition, for instance a few softened and ground match-heads, mixed with zinc oxide (to hold back sulphuretted hydrogen), are placed in the test-tube *a*, which is surrounded by warm water at 50°; after the electroscope has been charged, air is blown through about ten times successively with the aid of a rubber ball, or the air can be drawn through by connecting an aspirator, care being taken to place a bottle of several litres capacity, to catch any solid matter that might get sucked over, between the aspirator and *c*.

In the presence of the smallest quantities of ordinary phosphorus, the electroscope will be discharged, that is to say, the aluminium leaves fall together suddenly. Under normal conditions this takes place only slowly. The leaves ordinarily move through 0·2 to 0·5 divisions of the scale in five minutes.

The following method for the detection of white phosphorus in matches is based upon that of Aronstein. One hundred or more

match-heads are moistened with water, and then boiled with carbon disulphide for two hours under a reflux condenser. The cooled extract is filtered through a dry filter paper into another flask, and the carbon disulphide distilled off on a water bath. The flask containing the residue is at once connected with an apparatus by which, firstly, carbon dioxide, and secondly, dry air can be introduced. While the current of carbon dioxide is driving off the small quantity of carbon disulphide remaining in the flask, the temperature of the water in which the flask is immersed is gradually raised from about 15° to 30°. The room having been previously darkened, dry air is admitted into the flask at different and increasing temperatures, the current of carbon dioxide meanwhile being almost entirely turned off. Careful watch is kept for any sign of luminescence. If there be none at 30°, the temperature is gradually raised. In most cases, when white phosphorus is present, luminiscence is seen below 35°; very occasionally it may first appear at as high a temperature as 55°. The glow temperatures observed in two experiments (December 1910), with matches containing white phosphorus, were 23° and 25° (E. G. Clayton). The lowest limit of glow for phosphorus sesquisulphide, in the absence of white phosphorus, is generally about 60°,[1] so that this process can be applied to the detection of small quantities of white phosphorus in the presence of considerable amounts of phosphorus sesquisulphide.

According to C. Van Eijk,[2] a tube containing phosphorus sesquisulphide is not luminescent below 70°, but if 0·02 per cent. of white phosphorus be present a glow appears below 60°. An alternative plan is to extract with carbon disulphide, evaporate off the solvent, and distil the residue with a solution of lead acetate. Sesquisulphide of phosphorus is decomposed, and luminescence appears only in the presence of white phosphorus.

T. E. Thorpe's Sublimation Test for white phosphorus is carried out as follows :—A few grams of the match-heads, or of the composition, are dried thoroughly over sulphuric acid in a desiccator filled with carbon dioxide, and transferred to a bulb of 25 c.c. capacity blown on the end of a tube 20 cm. long and 15 mm. in diameter. Dry carbon dioxide is introduced, the apparatus evacuated as completely as possible, and the end sealed off. The bulb is then gently heated for two hours at from 40° to 60°. Phosphorus, if present, will be volatilised, and condensed in the upper part of the tube as a transparent, highly refractive sublimate of octahedral or dodecahedral crystals. It is claimed that this is the most trustworthy test for the presence of small quantities of ordinary phosphorus in the striking compositions of matches containing phosphorus sesquisulphide.

The test of Phelps is more sensitive than the above for small quantities of phosphorus, and it is more rapid when a large number of samples require examination. It is based on the volatility of white phosphorus in a current of steam and its luminescence with oxygen. 0·1 mg. in 10 c.c. of water can be detected. Hydrogen after washing with alkaline pyrogallol is passed into boiling water containing ten to twelve match-heads. The gas issues through a fine capillary at a relatively high velocity. The capillary is enclosed in a dark chamber and is viewed through a small microscope. The upper two inches of the capillary are heated electrically to prevent condensation. The method is applicable in the presence of nitrates, chlorates, hydrogen sulphide (phosphorus sesquisulphide), or carbon disulphide.

C. TESTS FOR CYANOGEN COMPOUNDS

When soluble cyanides or ferro- and ferri-cyanides are distilled in the presence of potassium chlorate, with sulphuric acid, free hydrocyanic acid is found in the distillate; insoluble substances of this nature, such as Prussian and Turnbull's blue, and "the spent oxide" of gasworks also are decomposed. Accordingly, when testing for cyanogen compounds, 1 g. of the scraped match-heads is treated with 50 c.c. of warm water and filtered, and both the filtrate and the residue distilled separately with dilute sulphuric acid. Hydrocyanic acid can be identified in the distillate by the following reactions:—

1. *Prussian Blue Reaction.* To the distillate is added a drop of ferric chloride and a drop of ferrous sulphate solution, or only a drop of ferrous sulphate solution, as this generally contains a little of the ferric salt; this is then made alkaline with a little sodium or potassium hydroxide, well shaken and carefully acidified with hydrochloric acid. In the presence of hydrocyanic acid, a precipitate of Prussian blue is formed, or the liquid turns green and deposits blue flakes on standing.

2. *Thiocyanate Reaction* (Liebig). Another portion of the filtrate is evaporated on the steam bath with sodium or potassium hydroxide and a little yellow ammonium sulphide; any hydrocyanic acid present is converted into sodium or potassium thiocyanate, which, when taken up with water and a little hydrochloric acid, gives a deep blood-red coloration on the addition of a drop of ferric chloride.

3. *Nitroprusside Reaction* (Vortmann [1]) To another portion of the distillate a few drops of potassium nitrite are added, then two to four drops of ferric chloride, and enough dilute sulphuric acid to convert the yellow-brown colour into pale yellow. The liquid is heated until it just begins to boil, cooled, a little ammonia added (enough to precipitate the excess of iron), and filtered. Two drops of dilute, colourless, ammonium sulphide are then added to the filtrate; a violet coloration, changing to blue, green, and yellow, shows the presence of hydrocyanic acid. Very small quantities give only a bluish-green or a greenish-yellow coloration. This reaction is the reverse of the well-known nitroprusside test for sulphuretted hydrogen and alkali sulphides, and is based on the conversion of any cyanogen present into potassium nitroprusside, $K_2Fe(NO)(CN)_5$, which is a very delicate reagent for alkali sulphides.

4. *Silver Nitrate Reaction.* The distillate is treated with nitric acid and silver nitrate; the presence of hydrocyanic acid is shown by a white precipitate, which should be stable to the light, and readily soluble in ammonia and potassium hydroxide.

D. QUANTITATIVE ANALYSIS OF MATCH COMPOSITIONS

The composition, without any previous softening with water, is carefully separated from the splints, with a sharp knife, care being taken to remove as little wood as possible, and weighed. Or the weight of the head can be estimated by drying several cut-off match-heads in a desiccator over sulphuric acid, and weighing them, then removing the heads with warm water, and drying and re-weighing the pieces of wood.

The estimation of free white phosphorus is carried out, as described on p. 137, and that of the other constituents by the usual methods. For the estimation of potassium chlorate, 0·5 g. of the composition is washed several times with 50 c.c. of water, a little potassium iodide (free from iodine) added, and one and a half times the volume of fuming hydrochloric acid. The whole is heated in a closed bottle for fifteen to twenty minutes on the steam bath, and when cold, the liberated iodine titrated with *N*/10 sodium thiosulphate.

VII. PHYSICAL TESTS

A. INFLAMMABILITY ON STRIKING SURFACES

Swedish and other safety-matches are supposed to strike only on the prepared surfaces on their boxes, but as a matter of fact they will ignite on several striking surfaces, such as hard wood, smooth hard paper, fine grained and not quite smooth stones, glass, porcelain, etc.

For tests carried out in Germany, the following materials were used:—A smooth board of beech wood 40 cm. long, a sheet of glass 40 cm. long, hard paper, the width of a match-box striking surface, 10 cm. and 20 cm. long, a fine grained plate of marble 15 cm. long, a slightly rough iron plate 15 cm. long, rough glass paper 5 cm. long, and fine grained glass paper 10 cm. long. To apply the test, the match is drawn with an even, gentle pressure slowly over the surface.

B. TEMPERATURE OF IGNITION

To ascertain the exact temperature at which matches will ignite is extremely difficult, on account of the various necessary precautions, and because concordant results are not obtained when the work is carried out under the same conditions. The temperature at which they will inflame of their own accord, in the case of white phosphorus matches, for instance, is lower as the percentage of phosphorus rises, and is more or less dependent on the distribution of the phosphorus in the composition. The more evenly the phosphorus is distributed throughout the composition, the higher will be the temperature of ignition; should a match-head contain a fairly large piece of phosphorus, it is possible for the temperature of ignition to be very little above that of phosphorus. On the other hand, it is known that, by continued careful heating in a current of air at about 70°, many kinds of matches lose their phosphorus, so that although the matches keep their shape and appearance, they are either almost unignitable or the temperature of ignition is found to be much higher than the real ignition temperature. Moreover, the better the matches have been varnished, the higher the temperature of ignition. The ignition point of badly varnished matches varies with the thickness of the coating. The temperature of ignition of any one class of goods can accordingly vary with the circumstances and the methods employed. A large number of tests should therefore be made, and an opinion given with very great care.

The apparatus used in Germany consists of a double-walled, asbestos-covered aluminium box with a double-walled door, provided with a small pane of mica for the purpose of observation. It is provided with three tubes for thermometers, and for inserting the matches, which can be placed at any height inside the box. The apparatus is divided longitudinally inside into three sections by pieces of wire gauze, in the central one of which is placed the thermometer, and in the side ones the matches for testing. The wire gauze serves to protect the thermometer, as well as the neighbouring matches, from pieces of match composition which may fly off from matches which ignite at a lower temperature. The apparatus is heated by a regulated rose-burner.

Another form of apparatus consists of a glass vessel with a copper lid, in which four springs are arranged for carrying test-tubes. The thermometer can be inserted in the centre of the lid. The vessel is filled to about one-third with pure liquid paraffin. A copper wire stirrer passes through the lid. The matches to be tested are hung on the ends of copper wires in the test-tubes.

This apparatus is similar to that described for explosives (*cf.* p. 71 of this Vol.).

In testing sulphur matches and wax matches, the sulphur or wax should first be removed, as the wax in every test, and the sulphur when the temperature became too high, would melt, and enclose the match-head.

The determination of the ignition temperature can also be carried out by the method devised by Leyque and Champion. A copper rod, which is to be heated at one end, has at the other end indentations, 10 cm. apart; these concavities or holes are filled with oil or with d'Arcet's alloy (sometimes called Newton's alloy), consisting of 8 parts of bismuth, 5 parts of lead, and 3 parts of tin, and melting at 94·5°. The rod is provided with six holes, and has a length of about 70 cm. from the first hole. Thermometers are inserted in the holes, and that point on the rod is found at which the match composition will ignite.

C. BEHAVIOUR UNDER PERCUSSION

K. Fischer recommends a method by which the results can be expressed in figures. He uses a striking apparatus, consisting of an oak block, partly filled with lead, and protected beneath by an iron plate; this runs in two iron grooves, from a height that can be varied, and falls on to an iron plate on which the match is placed. The height of fall, multiplied by the weight of the block, gives the force necessary to ignite the match in kilogram-metres. The height of fall is 1 metre; the weight of the block can be increased as desired by addition of lead. The greatest weight of the block is 1·5 kg., so that the largest amount of work which the machine can do is 1·5 kg.-metres. The results are not very accurate, as several circumstances, friction, for example, are not taken into account. However, as these errors are the same in each test, the results are comparative. The sensitiveness of one and the same class of matches under percussion varies very widely. Matches

of the same class with large heads ignite more readily than those with small heads. In general, the scraped-off composition is more easily ignited than the match, so that in forming conclusions from this test as much care must be exercised as in judging the temperature of ignition. For a general review of the influence of shock on explosive materials see *Przemysl. Chem.*, 1936, **20**, 117; *Chem. Abstr.*, 1937, **31**, 2435.

D. SENSITIVENESS TO MOIST AIR

To test this property the matches are placed in a vessel over wet cotton wool, and the vessel then placed under a bell jar over a vessel of water. Observations are made with regard to the behaviour of the matches when moist, their durability, appearance, stickiness, and the like.

E. BEHAVIOUR WHEN TREATED WITH CONCENTRATED SULPHURIC ACID BY MOISTENING OR BY IMMERSION

Observations are made as to whether inflammation of the match-head takes place with this treatment.

B. PRIMINGS AND FIREWORKS

Fireworks, so far as their active contents are concerned, are derived from a comparatively small number of components or mixtures (firework mixtures).

These comprise, on the one hand, easily combustible substances, such as charcoal, sulphur, antimony sulphide, resins, and tar; and on the other hand, they include substances which readily give up oxygen and support combustion, such as saltpetre (potassium nitrate), and potassium chlorate or other chlorates. A third category includes those substances used for the various colour effects (barium, strontium, copper, and other salts), and also finely divided metals, and coarse particles of charcoal, to cause sparks and showers of fire ("golden rain," and the like). Other substances are sometimes used to decrease the rate of burning and to increase brilliance (*e.g.* mercurous chloride and mercuric thiocyanate).

I. FIREWORK COMPOSITIONS

The following substances form the groundwork of most firework compositions:—Gun-powder (grain powder and meal powder), saltpetre and sulphur, charcoal mixture, and grey mixture.

A. GUN-POWDER

Ordinary coarse-grained gun-powder (grain powder) is used for impulsive or percussive charges (for throwing fireworks from bombs, mortars, etc.), or for explosions; the coarse-grained powder is necessary in these cases as quick combustion and a rapid evolution of gas are required.

Further, meal powder, that is, a finely powdered blasting powder, is used; that employed by makers of fireworks is of varying composition. For instance, a blasting powder is used, which, powdered and passed through a 0·5 mm. mesh sieve, consists of:—

60·2 parts by weight of doubly refined potassium nitrate.
18·4 ,, ,, of sulphur,
21·4 ,, ,, of alder wood charcoal,

and explodes at 20° by Wagner's powder test.

An ordinary blasting powder, consisting of 70 parts of saltpetre, 18 parts of sulphur, and 12 parts of charcoal is suitable. As a matter of fact, any ordinary gun-powder can be converted into meal powder, as its strength can easily be modified by the proportions of the ingredients. Meal powder is used when slow combustion is necessary. The qualitative and quantitative tests are carried out as detailed under Gun-powder (p. 29).

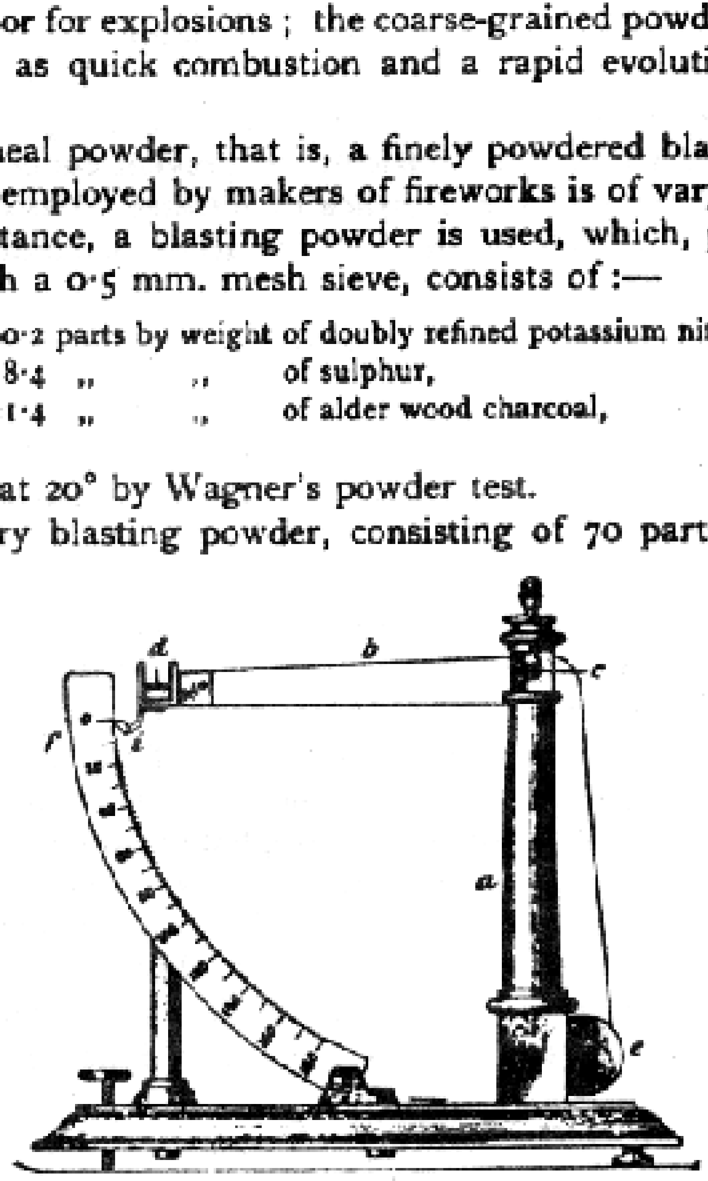

FIG. 10.

Wagner's Powder Test. In various factories, where fireworks are made, it is necessary, for some of the mixtures and for the calibre of the cartridges, to use a gun-powder of definite power. Tests by which the power can be estimated are carried out by means of Wagner's apparatus.

This apparatus (Fig. 10) consists of a column *a*, fastened to a

support, which can be levelled by means of screws; *b* is an angular lever, which moves on a hinge at *c*, and carries the counter-weight *e*. The unweighted arm *b* carries a small mortar *d* and a spring catch *i*, which moves over a graduated metal arc *f*. When the powder explodes, the arm is pressed downwards by the force of the explosion, and the distance through which it is displaced is shown by the spring catch. The number of degrees can be read directly from the graduated scale. The charge for each test is 2·2 g. of powder. The results obtained by this method are not very accurate, owing to the large size of the mortar, and the smallness of the charge; it is therefore necessary to repeat the test several times, and to take the mean of the results.

B. SALTPETRE AND SULPHUR

This is a mixture of 3 parts of nitre with 1 part of sulphur, and contains approximately equivalent weights of the two components. When this mixture, which yields very little gas, is burnt, the products formed are mainly potassium sulphate, sulphur dioxide, and nitrogen, in accordance with the following equation:—

$$2KNO_3+2S = K_2SO_4+SO_2+N_2.$$

This mixture is the basis for most compositions which are to give light, and also for grey mixture.

C. GREY MIXTURE

This is made by mixing 7 parts of meal powder with 100 parts of saltpetre and sulphur, and is mostly used for the manufacture of fire-balls (used in war). These consist of twill bags, charged with compressed grey mixture, which is filled into them with the aid of spirit; they are fired by means of a composition fuse. Grey mixture mixed with antimony sulphide is used for torches.

This material can be tested in the same manner as gun-powder (p. 29).

D. CHARCOAL MIXTURE

This name is given to meal powder, of which 500 parts are mixed with 6 to 8 parts of charcoal. To this class also belong the slow mixtures or slow fires, which consist of meal powder, the explosion of which is more or less retarded by additions of charcoal. Further, there are quick and slow squib mixtures, also so-called "green" mixtures, which are made up of various kinds of slow mixtures. The green mixtures contain larger proportions of sulphur. In addition there are propelling mixtures, which consist of meal powder, nitre, and charcoal (sometimes a little chlorate of potash), and spark mixtures, similar to the last, consisting of nitre, sulphur, and charcoal. The former are used for war rockets, and the latter for firework rockets. It is necessary that these mixtures should evolve large quantities of gas, and they are therefore made with a meal powder to which charcoal has been added. An old Prussian prescription for war rockets is as follows :—Thirty-two parts of nitre, 12 parts of sulphur, 32 parts of meal powder, and 16 parts of well-powdered charcoal.

Hence it is apparent that the charcoal mixture can be used, as these are very similar to the spark mixtures which consist of :—

Nitre	12 or 16 parts
Sulphur	3 or 4 ,,
Charcoal (coarse)	5 or 9 ,,

Spark mixtures are used for cases, constricted at one end, which can be suitably grouped and mounted, so as to be used for cascades of fire, suns, fans, palm trees, fixed stars, and various other kinds of fireworks. These mixtures are also made up with additions giving a reddish light, and with metal filings; those containing metals are known as "brilliant mixtures."

Finely divided metals, such as aluminium or magnesium, with various oxygen-containing substances, may be used for flashlights. Krebs uses zirconium with the nitrate and barium nitrate or other oxidant.

Such mixtures are analysed similarly to gun-powder. For tests for potassium chlorate, see Vol. I., p. 618, and for the examination of the various ingredients, nitre, charcoal, and sulphur, see pp. 1, 7, 8. The same points must be noted in judging these substances as in match mixtures.

The determination of aluminium in flares or dust may be carried out by the method of Faber and Stoddard by estimating the reducing power on litharge. The accuracy depends on the formation of a liquid slag from which the globules of lead can easily separate and on the temperature at which the assay is carried out. Three g. of aluminium is mixed with 100 g. of litharge and 30 g. of borax glass and a cover of 25 g. of borax glass added. The fusion takes 20 minutes in a gas muffle.

E. ILLUMINATION AND COLOURED FIRE MIXTURES

In addition to the substances already mentioned, these almost invariably contain potassium chlorate, together with substances, such as strontium, for producing the colours. Strontium salts give a red colour, barium salts a green colour, copper salts blue, and sodium salts (*e.g.* oxalate and carbonate) a yellow colour. For extra brightness, magnesium powder is added. They are accordingly mixtures of combustible substances with compounds which give coloured flames, and like exploding gun-powder, they throw off small particles which continue to burn while in motion, and owe their power of projection to the combustion. At first sight, it would appear easy to make one of these mixtures, but several factors have to be taken into account, such as the velocity of combustion, which in the case of "stars" should be great, for coloured lights slower, and for flames slowest of all; the temperature at which the substance imparting colour will act best; the formation of slags, and their fusibility. To find out whether these substances are suitable for colour mixtures, they should be thrown in the form of a dry and very fine powder into flames of varying temperatures such as hydrogen flames, the temperature of which has either been raised by oxygen, or lowered with nitrogen, so as to find out the effect of different temperatures. But this test is not always successful; for instance, lithium salts impart an intense carmine coloration to flame, but do not produce a colour of anything like the same intensity in mixtures. The manufacturer mostly tests this by making a small sample mixture, consisting of :—

Potassium chlorate	20 parts
Sulphur	5 ,,
Gum mastic	1 part

If the substance to be tested gives a good fire coloration with this mixture, it can probably be used.

The following formulæ have been found upon actual trial to yield satisfactory green and red colour mixtures respectively (E. G. Clayton) :—

	Green.	Red.
Barium nitrate	60	...
Strontium nitrate	...	63
Potassium chlorate	15	18
Sulphur	13	13
Realgar	11	...
Shellac	...	5
Charcoal	1	1
	100	100

Another green mixture is: barium chloride, 69 parts; lactose, 30 parts; shellac, 1 part. For a yellow light, a mixture of sodium nitrate, 20 parts; sulphur, 20 parts; antimony sulphide, 8 parts; and carbon, 2 parts, may be used. A mixture of powdered pitch, glue, and borax will give an intense yellow flame.

By mixing together combustible compositions, which give different colours, a tint is obtained, which is nearer to a white than to a mixture of the two colours. On mixing red and yellow a pale orange results; blue and yellow give a not very intense pale green; blue and red give violet, and this is the only good colour obtained by mixing; red and green give white.

For spark compositions the following can be used: nitre, sulphur, mealed gun-powder, charcoal, steel and other metal borings, aluminium, magnesium and various alloys, orpiment and antimony sulphide.

A number of phosphorescent light mixtures have been described by L. Vanino. The constituents are heated together for 1 hour, the number of parts being in parentheses :—*Violet-blue*: quicklime (15·0), strontium hydroxide (5·0), sulphur (8·0), magnesia (1·0), sodium carbonate (3·0), lithium sulphate (1·0), and 6 c.c. of 0·3 per cent. aqueous colloidal bismuth solution; or, alternatively, quicklime (17·0), strontium hydroxide (5·0), sulphur (8·0), lithium fluoride (1·0), magnesia (1·0), 1·0 c.c. of 1 per cent. rubidium nitrate solution, and 6 c.c. of 0·3 per cent. colloidal bismuth solution. *Violet*: quicklime (20·0), barium hydroxide (10·0), sulphur (9·0), sodium sulphate (1·0), potassium sulphate (1·0), lithium sulphate (1·5), 2 c.c. of 0·5 per cent. alcoholic bismuth nitrate solution, 1 c.c. of 0·5 per cent. aqueous thallium sulphate solution, and 0·5 c.c. of 0·5 per cent. aqueous thorium sulphate solution (the nitrates may be substituted for thallium and thorium sulphates). *Blue*: strontium hydroxide (15·0), quicklime (5·0), sulphur (8·0), magnesia (1·0), sodium carbonate (3·0), lithium sulphate (1·0), and 6 c.c. of 0·3 per cent. colloidal bismuth solution. *Green*: strontium hydroxide (20·0), sulphur (8·0), magnesia (1·0), sodium carbonate (3·0), lithium sulphate (1·0), and 6 c.c. of 0·3 per cent. colloidal bismuth solution.

Among non-chlorate colour compositions, in addition to these already mentioned, are some containing borax.

Smokeless flash powders have also been described containing up to 28 per cent. of zirconium, zirconium hydroxide and magnesium, barium nitrate, barium oxide and rice starch.

The presence of sodium compounds in certain flame pyrotechnics is to be avoided on account of the masking influence of the sodium flame and also on account of the hygroscopic nature of sodium nitrate which might interfere with the proper functioning of the pyrotechnic. The sodium nitrate can be estimated by the method of Ball. When a mixture of potassium nitrate, bismuth nitrate and cæsium nitrate in nitric acid is added to a dilute solution of sodium nitrate, even in presence of large amounts of potassium salts, the sodium is precipitated quantitatively in a crystalline form as cæsium sodium bismuth nitrite ($5Bi(NO_2)_3 . 9CsNO_2 . 6NaNO_2$). An improved technique has been described by Faber and Stoddard.

F. POTASSIUM CHLORATE AND SULPHUR

This consists of a mixture, used for adding to illumination mixtures, of 125 parts of potassium chlorate and 35 parts of sulphur. The use of chlorates is restricted in mixtures on account of their sensitiveness and has been made illegal in some countries.

G. "COLD" AND "WARM" MIXTURES

If the components are simply mixed together, the mixtures are known as "cold" mixtures. "Warm" mixtures are those made by fusing the substances together. The following is a "warm" mixture:—Grey mixture, 85 parts; meal powder, 29 parts; and antimony sulphide, 5 parts. This is used for fire balls and for white fire. Bengal lights are also often made by fusion.

H. IGNITION MIXTURES

These are for the purpose of firing inflammable objects at a distance. They must be made in such a manner as to combine the property of burning slowly with the development of as high a temperature as possible. The mixture used in Prussia for this purpose consisted of 76 parts of grey mixture and 24 parts of colophony. In Bavaria a combination of meal powder with "warm" mixture was customary.

I. MIXTURES FOR SPECIAL FIREWORKS

The following mixtures are used. For fuses, a mixture of meal powder, charcoal, and mica; for "golden rain," meal powder, charcoal, and iron filings; for "silver rain," lead nitrate, potassium nitrate, and charcoal; for "comets" a little meal powder and charcoal. Picric acid mixtures were introduced by Dessignolle and Castelaz, by Brugère, and by E. Jacobsen, for causing detonations with coloured fires. With copper powder, green sparks are obtained; with magnesium, white; and with zinc, bluish-white.

The first named used ammonium picrate together with barium nitrate, strontium nitrate, etc.; the last used the picrates of strontium and barium, which, however, have to be fired by means of a fuse. These mixtures are best made by the manufacturer himself from picric acid and the respective carbonates. For the testing of picric acid, see p. 44.

A mixture of calcium nitrate and carbonate, potassium nitrate, magnesium or aluminium red lead and calcium resinate may be used as a tracer mixture.

Whistling squibs are made with magnesium picrate. The mixture is prepared according to the formula of the inventor, Weiffenbach, of Stuttgart. Two hundred grams of picric acid and 800 g. of nitre are dissolved in hot water, and saturated with 30 g. of magnesium carbonate, and the precipitated crystals then dried.

Hexamethylenetetramine may be substituted for charcoal, shellac, dextrin, or sugar in pyrotechnics, especially in fireworks for indoor display. Charred woodmeal or sawdust may also be used.

A typical smoke composition is as follows: tetrachlorethane or chloronaphthalene, 40 to 50 per cent.; zinc filings, 35 per cent.; nitre saltpetre, pitch and calcium silicate, 15 per cent.

As an example of a detonating firework composition the following may be given ; phosphorus sulphide is mixed with an oxidant and an inorganic binder consisting of magnesium oxide and an alum.

J. MERCURY FULMINATE (see p. 59)

This is used for percussion caps, either alone, or mixed with other combustibles ubstances, or with gun-powder, potassium chlorate, nitre and sulphur, etc. These additions serve the purpose of retarding the decomposition, and of increasing the volume of the gases formed. Percussion caps are made of thin rolled copper sheet. The following is a prescription for this mixture:—One hundred parts of mercury fulminate are rubbed into a paste with 30 parts of water on marble slabs with boxwood rubbers; to this are added 50 parts of nitre, or 62·5 parts of nitre and 29 parts of sulphur. The paste is dried on sheets of paper, and granulated by means of hair sieves. Some makers, after placing the grain in the percussion cap, cover it with a small copper plate, while others coat the grain with mastic varnish. Discs of varnished tinfoil, or paper, or of both together, are sometimes used. One kilogram of mercury after conversion into the fulminate is sufficient for 40,000 percussion caps.

Analysis of Mixtures containing Mercury Fulminate. F. W. Jones and F. A. Wilcox advise, in a mixture containing potassium chlorate, the fulminate, and antimony sulphide, first to extract the fulminate of mercury from a weighed quantity by means of a solution of ammonia in acetone, then the chlorate with water, and to weigh the residual antimony sulphide.

Chlorates are usually determined by conversion to chlorides by a suitable reducing agent and estimation as silver chloride; or by heating with excess of conc. hydrochloric acid, when the gases evolved set free an amount of iodine (estimate with thiosulphate) from potassium iodide equivalent to the weight of chlorine present in the gases evolved. For the presence of potassium perchlorate in ammonium nitrate and chlorate mixtures the method of Bunge may be employed: 100 c.c. of an aqueous extract of the explosive is mixed with 20 to 25 g. of powdered quartz, the mixture is evaporated to dryness and ignited. Potassium is then determined in an aqueous extract of the ash by the perchlorate method, a correction being made for any potassium chloride or nitrate originally present in the explosive. For rapidly determining perchlorate alone in explosives containing only small amounts of other potassium salts and nitroglycerin, 5 g. of the explosive is mixed with 20 g. of powdered quartz, and the mixture is heated in a quartz crucible. The ammonium salts are thus decomposed, and the aqueous extract of the ash is analysed as before.

H. Brownsdon estimates the mercury fulminate by decomposing it with excess of sodium thiosulphate, and determining the resulting alkalinity by *N*/10 sulphuric acid, previously standardised against pure fulminate.

The method has been improved by Philip. He dissolves the fulminate in a large excess of potassium iodide and a known volume of a standard solution of sodium thiosulphate is also added. The excess of thiosulphate is titrated with standard iodine solution after neutralisation with standard acid.

Marqueyrol [4] extracts the mixture containing mercuric fulminate and other compounds with a 5 per cent. solution of potassium cyanide. The extracted mercury salt is electrolysed and the mercury estimated in the usual way.

The explosive properties of fulminate of mercury have been studied by Berthelot and Vieille, who give the following equation for its decomposition :—$(CNO)_2Hg = Hg + 2CO + 2N$. When mixed with 30 per cent. of water, it can be rubbed on a marble slab, with a

wooden rubber, or a soft, clean cork, without any danger.

The following are the results, in round numbers, of a series of analyses of several kinds of percussion caps, in one of which lead thiocyanate had been used instead of mercury fulminate (E. G. Clayton) :—

	1.	2.	3.	4.	5.
Mercury fulminate	33	21	25	27	...
Lead thiocyanate	...	...	...	...	36
Antimony sulphide	15	45	34	...	...
Sulphur	...	...	...	7	...
Ground glass	...	...	18	43	...
Potassium chlorate	52	34	23	23	64
	100	100	100	100	100
	G.	G.		G.	G.
Approximate weight of charge per cap	0·025	0·046	...	0·022	0·025

In these analyses, Brownsdon's method was employed for the determination of the fulminate, the antimony was estimated volumetrically, the lead gravimetrically, and the thiocyanic acid by a colorimetric method ; the figures for potassium chlorate were obtained by difference.

II. DETONATORS

Initiating explosives (detonators, including railway detonators) may be examined by the Esop test. In this test, the detonator is mixed with varying amounts of an inert substance (*e.g.* talcum) until a number of cartridges of a mixture do not detonate regularly when fired with the detonator under examination. The two ingredients used in the test are picric acid and olive oil. The strength of the detonator may also be measured quantitatively by the Wohler test. The initiating effect on 2 g. of trotyl (trinitrotoluene) or troxyl (trinitroxylene) mixed with paraffin is measured. Equal weights of the explosive (*i.e.* trinitrotoluene) are mixed with a standard paraffin oil to give a series of samples with varying paraffin-oil content. The explosion is carried out with 2 g. of each grade of trotyl in a copper tube of 10 mm. diameter placed on a plate 5 mm. thick. The maximum percentage of paraffin oil which still allows complete detonation is taken as a measure of the strength of the detonator.

III. PRIMINGS

A. THE FIRING-EXCITER

This consists of a mixture of meal powder and alcohol. A fast exciter consists of 1000 g. of meal powder and 570 c.c. of alcohol ; a **slow exciter of 1000 g. of meal powder and 720 c.c. of alcohol. These mixtures are best made with the hands in a copper pot, or in a porcelain basin. The exciter is painted on to the quick match at the firing hole, where the paper of the covering of the firework has been twisted together, for instance where the fuse is fastened to crackers and squibs. In general all those places which are intended to catch fire are painted with this mixture. If it is intended to stick tightly, a solution of 16 g. of gum arabic in 140 c.c. of water is added. The tests used are similar to those employed for gun-powder (p. 29).**

B. SLOW AND QUICK MATCHES, FUSES

Triple and quadruple cotton threads, purified from grease as for gun-cotton, are soaked in quick firing-exciter, and sprinkled with meal powder. After the impregnation they are allowed to lie for six to eight hours, then rolled on a bobbin and passed through a board, provided with holes of various sizes, so as to impart the required strength and uniform thickness to the threads after air drying. They are again passed through the firing-exciter, which has been thickened with gum arabic, then again through the holes in the board, sprinkled with meal powder and dried ; finally they are wrapped in paper, placed in dry boxes, and stored in a dry place. According to the formula used for the Prussian artillery, the following quantities are necessary for a fuse 100 metres long, and 0·52 cm. in diameter :—2·94 kg. of meal powder, 4·35 litres of alcohol, 21·2 g. of gum arabic, and 0·24 kg. of cotton thread. Thus prepared, the speed of burning is 1 metre in 24 secs.

Better fuses are obtained by a previous treatment of the cotton with a special mordant (cf. *infra*).

In the case of a ***train of powder*** (or ***leader***) the fuse is covered. These covered fuses protect the firework against pre-ignition, and also cause a quicker firing. For this purpose the fuses are covered with paper tubes.

Quick Matches or ***Paper Fuses*** are made of cotton wick boiled in a solution of gum and mealed powder and partly dried. The wick is then dusted with mealed powder. It may be used in this form or enclosed in a tube, when it burns more rapidly (approximate rate : 1 foot in 1 to 3 secs.). As a rule, they are about 28 cm. long, and 0·33 to 0·21 cm. in diameter.

The Mordant for Fuses **serves in the first place to make the fuse more inflammable, and secondly, to ensure a steady and quiet combustion, for instance, as in time fuses. The mordant consists of a solution of 1 part of nitre in 10 parts of water. The dry cotton threads are allowed to remain in this solution for twelve hours, and are then wrung out and dried.**

Slow Matches as prepared for pocket match boxes, are obtained by boiling loosely spun cotton in a solution of lead nitrate, consisting of 1 part of lead nitrate in 10 parts of water or in potassium nitrate ; they are then allowed to dry in the air without being wrung out. Another method consists in boiling the cotton in a solution of lead acetate (1 part of lead acetate in 20 parts of water) and when dry, placing them in a solution of 1 part of potassium bichromate in 10 parts of water. The threads so made are yellow, owing to the formation of lead chromate. This fuse smoulders at the rate of about 1 foot in 3 hours, and used when a long delay is required.

In the Sheune fuse lead tubing is filled with powdered trinitrotoluene. The explosive is melted and drawn into the tube by suction, and when cold the tube is drawn out to a diameter of 4 mm. The tube may also be filled with molten trinitrotoluene and allowed to cool. The length is increased by hammering. The temperature of the explosive is kept below its melting point during the treatment and a current of air directed on the tube. In this way a more sensitive *cordeau* or fuse is obtained.

Electric fuses are also used.

Fuse Paper. In dry weather this can be used in place of the ordinary fuses, and finds general use for certain firings. It is made by spreading firing-exciter on to both sides of sheets of blotting paper, sprinkling it with meal powder and drying it.

C. GUN-COTTON FUSES

The preparation of gun-cotton fuses is exactly the same as that of gun-cotton. They can be tested as described in the section on Nitrocellulose (p. 32). These fuses transmit fire faster than any other form, and are mostly used for firing large set-pieces ; they burn very fast, and will fire a fuse-paper wrapped round them with absolute certainty ; they have the further advantage that they can be used in wet weather.

D. PORT-FIRES

These are fireworks which will cause the firing of charges and of other fireworks quickly and safely in cases where the fuse cannot be used. Port-fires must therefore be capable of burning very well, and must not be put out by even the strongest shower of rain. The mixtures employed must be very rich in oxygen, and it is recommended to fuse together the nitre and sulphur mixture used in their manufacture.

Port-fires are about 40 to 50 cm. long, and should give a flame 8 mm. long. The necessary casing is made of strong cardboard, and is soaked in a solution of nitre so that it should burn easily; the diameter is about 1 cm. The mixture is filled into these cases, about 5 cm. deep at a time, and slightly compressed: sometimes it is moistened with linseed oil. The composition of some typical port-fires is as follows :—

	Swedish Mixture.	French Mixture.	Prussian Mixture.
Nitre	24 parts	6 parts	100 parts
Sulphur	14 ,,	3 ,,	100 ,,
Meal powder	11 ,,	1 part	85 ,,
Colophony	1 part	...	7 ,,

E. COMPOSITION FUSES

These are really only port-fires on a smaller scale; they are fastened to fireworks and effect a certainty of firing. They are made of strong paper, have a diameter of 0·5 cm. and a length of from 6 to 8 cm. They are filled up to 2 to 3 cm. with meal powder, on the top of which a layer of priming-mixture is placed. Such mixtures consist of :—Nitre and sulphur, 100 parts; meal powder, 25 parts. The mixtures used for time fuses can also be employed.

F. TIME FUSES

Many fireworks (set pieces) can only be successful and produce the desired effect if some parts, such as torches, squibs, etc., have a definite time for burning. Time fuses are used for exploding charges, or for igniting fireworks in a definite period of time. These time fuses are tubes filled with a mixture in such a manner that a certain length will burn in a definite time.

As in the case of igniters, the differences in the action of time fuses are based solely on the proportions of a few constituents (powder, nitre, sulphur, etc.), and upon the density of the mixtures. Their examination is conducted as described above. The main requirement in the case of these fuses is to determine the time of burning.

IV. The Duration of Burning

In fireworks, the maintenance of a definite duration of burning is especially necessary where set pieces are used, or where rotations are required and the like. It is less necessary in the case of rockets, when they are to be let off together in the form of a fan, etc., or in a quantity of squibs, because the composition and compression of the mixtures used are sufficient to regulate the combustion. The duration of burning of a mixture is dependent upon :—

1. The composition.
2. The degree of dryness.
3. The degree of fineness, and the thoroughness of mixing.
4. The degree of compression.
5. The area of its burning surface.
6. The area of the delivery opening.
7. The nature of the covering.

From this it is obvious that successful results can only be obtained by working with uniformly made mixtures, with the same covering material, and uniform charging. Small divergences nevertheless occur, but these can be neglected, as they make no difference, when the firework is ignited. Moisture in the mixture retards the firing, not only directly by its presence, but also because it causes reaction, mainly between the sulphur and the metals in the mixture, when the fireworks are stored. The area of the delivery opening retards the firing when it is less than ½ to ⅓ of the area of the case.

The duration of burning is determined with a stop-watch, and is of importance in the case of set pieces, in which several kinds of mixtures are present. The time can then be regulated by altering the depth of the mixture in the cases; shorter cases for slower mixtures, and longer cases for quicker mixtures, can be used.

V. Testing Firework Mixtures for Liability to Spontaneous Combustion

Some compositions used in the manufacture of fireworks have pyrophoric properties; for example, mixtures containing iron filings and sulphur, which have become damp; also certain Bengal light mixtures. Illumination mixtures containing nitrate of strontium or barium, sulphur and potassium chlorate, will often fire of their own accord, after standing for a few hours. This occurs chiefly when the ingredients have been quickly dried before use, and when the mixture is left lying in a warm, moist place. An ignition of this nature can be prevented by making the mixture of pure materials. A better preventive, according to Clarke, is an addition of a small quantity of antimony sulphide, or of a small quantity of sodium carbonate or chalk, as in the case of nitrocelluloses. The latter take up any acid impurities of the sulphur or other components, and form compounds which are inactive with chlorates and nitrates. This treatment is of some use, but the action of antimony sulphide is questionable. Mixtures which have become damp, must be dried separately and with great care, as they ignite easily. Mixtures containing copper oxide also fire readily, but this can be prevented by substituting copper carbonate for the oxide. Traces of permanganate or bromate are also dangerous.

The test proposed by Meischmeier is carried out as follows :—Five grams of the mixture is slowly heated in a dish on a sand-bath, to 100°, and kept at this temperature for two hours. If it is now moistened with water, and again dried, it should not ignite spontaneously.

Explosives, Matches, and Fireworks

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